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PAPERS.

I. *Longitude of the Honourable East India Company's Observatory at Madras.* *By T. G. Taylor, Esq. F.R.S. and F.R.A.S.*

Read June 13, 1845.

An accurate determination of the longitude of the Madras Observatory is a want which, particularly of late years, has been duly acknowledged and felt, not only in an *astronomical*, but equally so in a *geographical* point of view; since, in the former case, any error in the value assumed in the comparison of the places of the moon and planets with the tables necessarily led to seriously mischievous results; and in a geographical point of view, the triangles in the great trigonometrical survey of India depend for their zero or point of departure upon the meridian passing through the Madras Observatory: the inquiry must, hence, be considered one of singular importance. On my arrival at Madras, in 1830, the determination of the longitude of the Madras Observatory by my predecessor (Mr. Goldingham), being deduced from no less than 230 observations of the eclipses of *Jupiter's* first and second satellites, and about 800 lunar distances, it appeared more than probable that its correction (if any were required) must necessarily be of very small amount; and, before a result derived from so large a number of observations could with safety be disputed, it was desirable to meet the inquiry with at least something like a corresponding number of observations: this, however, was a work of years to accomplish; hence the necessity of having recourse to some more satisfactory and expeditious method than that of eclipses.

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On the erection of the present five-feet transit instrument, in 1831, without entertaining any serious hopes or expectations of amending the then received longitude, I commenced the observations of "Moon-culminating Stars;" and, computing from the observations of that year and the corresponding observations at Greenwich and Cambridge, the longitude came out $5^h\ 21^m\ 3^s{\cdot}7$, or about *five seconds of time less* than the value assigned by Mr. Goldingham.* To results thus obtained, however, I was then little inclined to give that degree of credit which later experience has shewn them to deserve; my reasons for doubt arose from considerations which it may not be improper I should here state. I had noticed that the diameter of the sun, as measured by different observers, was subject to considerable variation; if the same occurred with the moon, the determination of the longitude from the observations of the first limb *alone*, would necessarily be affected by a constant source of error, which repeated observation would not eliminate: it was probable, however, that the positive error — personal equation it may be termed — committed by an observer on the *first* limb, might be counterbalanced by a similar but *negative* error in the observation of the second limb; and the occurrence of this circumstance was indispensable to the accurate determination of the longitude. Whether such compensating effect does accurately take place, or whether observations of the moon are subject to the same extent of error as those of the sun,† must still remain among the matters of doubt; but, as far as the present observations go, it appears that discrepancies arising from this source are confined within rather narrow limits, inasmuch as the semidiameter of the moon, as measured at Madras, does not differ more than ($0''{\cdot}5$) half a second of space from that observed at Greenwich, Cambridge, Edinburgh, and Hamburg. In the early volumes of the *Madras Results*, it had been my practice to give the observations of the moon-culminating stars and eclipses of *Jupiter's* satellites, together with the longitude, as deduced therefrom, as far as circumstances would permit; but the extreme irregularity with which the corresponding Greenwich observations came to hand, rendered these results in some cases incomplete; and in the printing of Vols. IV. and V., not having received any of the Greenwich

* The longitude assigned by Mr. Goldingham was $5^h\ 21^m\ 8^s{\cdot}8$.

† The existing effect of the sun's rays, even when viewed through an appropriate dark glass, may, in the case of weak eyesight, occasion an ill-defined image of the limb, from which a stronger sighted observer would be free.

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observations, the continuation of the series was necessarily interrupted. To supply this deficiency, however, Mr. RIDDLE (at the suggestion of Mr. BAILY) had undertaken the reduction of the corresponding moon-culminating stars for the years 1834–1837; and the results are given in Vol. XII. of the Society's *Memoirs*. In this paper, Mr. RIDDLE having at some length explained the particulars of the methods of computation employed, it will only be necessary for me here to refer to his paper, and to state, that the formula employed by him is precisely that which had been observed in obtaining the previous as well as the present results: there are one or two circumstances, however, in which I have differed from the practices observed by Mr. RIDDLE, which it may be as well here to explain. In cases in which the full moon has occurred in the interval between the moon's transiting the meridian of the Madras and the Western Observatory, it has sometimes happened that the first limb of the moon has been observed at Madras and the second limb at the Western Observatory; in these cases, Mr. RIDDLE has computed the sidereal time of the semidiameter passing the meridian from the semidiameter given in the *Nautical Almanac*, and deduced the longitude in the usual way. Fearing, however, that the semidiameter given in the *Nautical Almanac* might not represent the semidiameter due to observers at Madras or Greenwich, I have thought it better to reject the two or three observations in which this circumstance occurs. Again, in taking the means, Mr. RIDDLE has given to each result a weight equal to the number of stars observed, whereas I have made use of a table of weights depending upon the square root of the number of stars observed; the rapidity of change of the moon's right ascension $(t-\tau)$; and upon the relative accuracy of observations of the moon or stars. From the Madras Observations, I conclude that the mean error of any single observation of the moon is double that which may be expected from the observation of a star; hence, although the observation of several stars will eventually tend to produce accurate results, still it need not be expected that a result derived from several stars is necessarily very superior to another which may have been obtained from only one star.

In the paper by Mr. RIDDLE above alluded to, the few cases in which the second limb of the moon had been observed rendered it unnecessary that they should be separated from the far greater number of cases in which the first limb had been observed. On the present occasion, however, having succeeded in obtaining several observations of the moon's *second* limb, I have

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thought it desirable to effect a separation, so as to exhibit the result from observations of the first limb distinct from that derived from the second limb, and in taking the means (neglecting the variable amount of $(t-\tau)$, which is not given in Mr. Riddle's paper), when one, two, three, or four stars have been observed, I have allowed the weights 5, 7, 8, and 9, respectively.*

With a view of presenting the whole of the observations and results in one view, as well as to correct those of Vols. I. and II. (in which I had not considered it necessary to pay attention to third differences in the interpolation of the moon's place), I have in the present paper given the recomputed results for 1831–1833; so that Mr. Riddle's paper, with the present one, exhibits each single determination from corresponding observations at Greenwich and Cambridge from 1831 down to the end of 1844,† and at Edinburgh from the commencement to the end of 1839. It only remains for me to advert to another series of observations which has now been introduced, namely, the observations made at the Hamburg Observatory—these having been taken from the *Astronomische Nachrichten*, Nos. 503, 504, and 508, with which I have been obligingly favoured from an unknown source; and, finally, to reduce each series to the meridian of Greenwich, the following differences of longitude have been employed:—

Cambridge	−	0 m 23·54 s	(*Naut. Almanac*, 1845)
Edinburgh	+	12 43·60	(*Naut. Almanac*, 1845)
Hamburg	−	39 55·00	(*Conn. des Temps*, 1840).

* I have likewise corrected Mr. Riddle's paper for an error in the Madras Observation of the Moon on the 5th of October, 1835, thus:—

Column, Greenwich, 1835, October 5, *for* 45·0 s *read* 58·0 s
—— Cambridge, 1835, October 5, — 38·0 — 51·0

† For the latter observations at Greenwich and Cambridge, I am indebted to the obliging attentions of the Astronomer Royal and Professor Challis.

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These being applied to the means we get altogether as follows:—

Madras Observations compared with		☽'s First Limb.		☽'s Second Limb.	
		No. Obs.	Longitude.	No. Obs.	Longitude.
			h m s		h m s
For (1831–1833) (corrected)	Greenwich	10	5 20 52·88	1	5 20 65·20
	Cambridge	21	53·16	4	63.15
For (1834–1838) (See Vol. XII. R.A.S. *Mem.*)	Greenwich	49	55·01	5	59·74
	Cambridge	54	54·10	2	62·70
	Edinburgh	60	57·49	6	59·41
For (1838–1844)..	Greenwich	78	57·56	36	57·21
	Cambridge	97	56·67	25	59·51
	Edinburgh	39	58·01	5	51·02
For (1838–1840) ..	Hamburg	34	57·58	2	51·89

Giving to each result a weight proportional to the number of observations we get

From 442 observations of ☽'s first limb .... 5 h 20 m 56·38 s with a probable error of ± 0·23 s
— 86 ——— ☽'s second limb.. 58·19 ——— ± 0·57

Or, for the present, the most probable value for the longitude of the Madras Observatory, as resulting from the observations of moon-culminating stars, is

5 h 20 m 57·28 s

T. G. TAYLOR.

NOTE.

The above determination being less than that arrived at by the eclipses (as given by Mr. GOLDINGHAM), to the amount of eleven and a half seconds of time! I have been led to inquire what circumstances could possibly give rise to so large a discrepancy, and to which of the two methods it was chargeable. With regard to the method of moon-culminating stars, it seems to offer no permanent source of error where both limbs are observed; but the result from eclipses does not seem to be wholly free from objection, inasmuch as it appears (as far as my limited means of comparison permit) that the immersions of *Jupiter's* first satellite are seen *later* to the amount of n seconds, and the emersions *earlier* to the amount of $(n + 10)$ seconds with a 5-feet achromatic by DOLLOND now in use, when compared with the 42-inch telescopes with which Mr. GOLDINGHAM's observations were made; this effect being increased in the case of the second satellite would nearly account for the total disagreement found.

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Moon's First Limb at Madras and Greenwich.

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1831.	m s	s		1838.	m s	s	
Mar. 23	12 38·50	+54·06	26	May 7	10 9·67		
May 25	10 54·33	46·48	22		10 9·79	+54·85	25
June 20	10 34·60	52·27	22	June 2	9 39·82	68·28	19
Dec. 12	11 19·18	39·85	23	July 31	12 25·96	63·46	25
1832.				Sep. 3	12 50·45		
Mar. 13	13 29·85				12 50·19	52·72	33
	13 29·17	50·47	34	30	12 52·08		
April 13	11 29·66	58·86	25		12 51·95		
14	11 19·74	63·15	25		12 52·04	56·74	40
Oct. 8	11 2·81			Nov. 25	11 38·99	64·27	24
	11 2·63			Dec. 25	11 57·53	59·72	24
	11 2·69	57·80	34	28	14 16·15	55·14	28
Nov. 4	10 55·65	55·60	22	1839.			
29	10 52·53	47·05	22	Feb. 23	13 38·59		
1838.					13 38·97	52·46	34
Jan. 3	11 19·03	60·48	23	24	12 51·30	57·72	26
Feb. 2	12 24·71	57·60	25	Mar. 24	12 8·89	71·50	24
Mar. 6	12 4·64			April 25	9 32·41		
	12 4·95	82·00	30		9 32·54	41·59	24
9	10 6·02			26	9 40·31	55·63	19
	10 6·08	48·47	25	1840.			
10	9 44·04	31·04	19	Jan. 16	15 29·01	55·76	31
April 7	9 37·05	55·93	19	Feb. 12	14 57·09		
8	9 38·28	51·18	19		14 57·17		
9	9 53·63	45·33	20		14 57·17	44·54	46
May 2	10 31·60	63·30	22	13	14 51·81	57·82	30
3	9 58·72	69·10	20	April 11	11 27·21		
5	9 35·95				11 27·29		
	9 35·99	48·55	24		11 27·42	58·74	35
6	9 47·68			13	10 17·47		
	9 47·67				10 17·97	+44·67	26
	9 47·74	+49·76	30	15	10 12·51		

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Moon's First Limb at Madras and Greenwich (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.
1840.	m s	s		1842.	m s	s	
April 15	10 12·34			Oct. 11	11 47·66	+79·35	24
	10 12·51			Dec. 14	12 3·62		
	10 12·32	+56·40	36		12 3·65		
Oct. 7	10 54·76				12 4·04	60·23	37
	10 54·78	51·69	28	1843. Feb. 13	12 15·85		
9	11 9·86				12 15·89	60·71	31
	11 9·62			April 8	12 44·90		
	11 9·60	50·83	34		12 44·82	62·10	33
1841. Jan. 5	15 53·44			10	12 27·49		
	15 53·59	56·16	40		12 27·81		
April 2	11 52·64	51·03	24		12 27·85		
3	11 26·49				12 27·71	56·81	43
	11 26·20	58·46	28	13	13 12·93		
May 26	12 17·23	69·20	25		13 12·95	51·70	34
1842. Jan. 26	13 56·30			May 13	14 29·54	56·57	29
	13 56·56	65·61	35	June 10	14 25·33		
Feb. 21	14 32·90	57·60	30		14 25·54	60·24	36
May 20	12 2·05	62·09	24	Oct. 4	10 28·21		
22	12 59·64				10 28·11	64·27	26
	12 59·18	79·72	33	5	9 10·82	62·07	19
June 21	13 18·02			Nov. 29	10 12·41	62·36	21
	13 17·45			1844. Jan. 28	11 25·74	50·46	23
	13 17·65	48·48	41	Mar. 3	12 8·92	48·50	24
Aug. 15	12 57·89			28	12 0·95	63·06	24
	12 57·93	62·70	33	29	11 57·35		
16	12 30·11	55·31	26		11 57·43	54·97	30
Sep. 13	12 6·13			30	11 57·98		
	12 6·16	52·81	30		11 58·32		
14	11 24·50				11 58·61	55·20	37
	11 24·50	67·86	28	April 1	12 25·84		
15	10 45·80	50·81	22		12 25·89	58·32	31
16	10 15·76	+39·15	21	2	12 55·08	+54·65	26

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Moon's First Limb at Madras and Greenwich (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.
1844.	m s	s		1844.	m s	s	
April 28	11 57·47			Sept. 24	11 10·27		
	11 57·38	+65·00	30		11 10·19	+61·08	41
29	12 26·72			25	10 57·79	67·00	22
	12 26·61			Oct. 18	12 58·31	48·28	26
	12 26·61	69·55	38	22	10 52·13		
30	13 7·47				10 52·03		
	13 7·45	50·03	33		10 52·11	73·10	34
	13 55·97			25	11 2·79	59·04	22
May 1	13 55·97			Nov. 20	10 44·10		
	13 55·85	53·58	35		10 44·04	58·75	27
Sept. 20	13 23·23	+48·81	27	21	10 52·93	+54·13	22
24	11 10·16						

Moon's Second Limb at Madras and Greenwich.

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.
1831.	m s	s		1843.	m s	s	
Oct. 23	14 4·07	+65·20	28	May 13	14 30·40	+66·37	30
1838.				Oct. 14	12 21·96		
Feb. 9	10 29·46				12 22·16	62·50	31
	10 29·57	58·58	26	Nov. 8	11 58·17		
Mar. 11	9 34·46				11 58·17	59·71	30
	9 34·77	44·54	24	11	12 11·90	66·66	25
1842.				1844.			
May 24	13 32·89			Jan. 10	11 46·28		
	13 32·58	56·69	34		11 46·20	53·73	29
June 26	10 16·66	55·88	21	Mar. 5	12 30·71	56·48	25
Nov. 18	13 3·86	66·81	26	6	12 55·48		
Dec. 18	13 42·90	57·17	28		12 55·21	61·47	33
23	11 50·56	51·72	24	7	13 24·85	+53·09	27
1843.				April 3	13 32·26		
Feb. 16	12 38·78				13 32·21		
	12 38·75	62·77	32		13 32·45		
Mar. 17	13 23·39						
	13 23·48	+53·71	34				

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Moon's Second Limb at Madras and Greenwich (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1844.	m s	s		1844.	m s	s	
April 3	13 32·60	+46·73	48	Sep. 30	11 34·71		
5	14 36·48				11 34·75	+73·24	36
	14 36·47			Oct. 3	11 43·30		
	14 36·25	68·43	45		11 43·73		
6	14 38·40				11 43·44	61·05	36
	14 38·28	24·00	37	26	11 17·26	58·84	23
8	13 35·49	66·64	28	27	11 30·74	52·45	24
May 2	14 41·28	54·21	30	28	11 39·75	42·37	24
8	11 38·23	47·03	24	31	11 30·78		
June 4	12 22·78	61·88	25		11 30·66	59·89	30
Aug. 4	10 58·09	60·40	22	Nov. 3	11 11·00	47·61	22
Sep. 28	11 9·59			26	11 42·45	53·24	24
	11 9·72	52·22	22	27	11 34·18		
29	11 22·64	+63·67	23		11 34·25	+73·67	30
30	11 34·89						

Moon's First Limb at Madras and Cambridge.

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1831.	m s	s		1832.	m s	s	
Mar. 23	12 37·46	+27·38	26	Nov. 4	10 54·69	+27·75	22
May 25	10 53·41	20·33	22	1833.			
June 20	10 33·75	27·12	22	April 1	13 21·09	30·74	27
Oct. 17	11 50·47	29·62	24	28	13 6·98	28·81	26
Dec. 14	12 3·06	32·80	24	29	12 39·52	43·28	26
1832.				May 3	12 10·31		
Mar. 13	13 28·55	22·14	27		12 10·37	28·32	31
Sep. 4	11 41·18	51·36	24	June 29	12 14·89	31·51	25
5	11 35·73			July 1	12 23·72		
	11 35·84	20·45	30		12 23·54	54·02	31
Oct. 8	11 1·89			Sep. 26	10 26·12	20·28	21
	11 1·77	28·47	28	Oct. 20	11 57·63	+21·20	24
Nov. 1	11 6·20	+21·68	22	23	10 31·91		

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Moon's First Limb at Madras and Cambridge (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 20^m$.	Weight.
1833.	m s	s		1838.	m s	s	
Oct. 23	10 31·86			April 7	9 36·19		
	10 31·95	+24·22	33		9 36·06	+22·88	34
Nov. 19	10 42·80			8	9 37·61		
	10 42·94	25·61	27		9 37·62		
1838.							
Jan. 3	11 18·26				9 37·51		
	11 18·45				9 37·57	27·20	34
	11 18·28	41·33	35	9	9 53·11		
4	11 30·76				9 53·11		
	11 30·85				9 53·27	30·10	31
	11 31·05			May 3	9 58·11		
	11 31·00	30·67	41		9 58·01		
5	11 56·73				9 57·84	44·64	31
	11 56·87			5	9 35·48		
	11 56·87				9 35·29		
	11 56·81	24·70	42		9 35·48	30·24	30
Feb. 4	13 1·99			7	10 13·88	22·29	21
	13 1·65	38·66	33	Aug. 2	14 21·53		
8	11 9·55	27·22	23		14 21·76	29·41	36
Mar. 6	12 3·65			Sep. 3	12 49·37		
	12 3·89	34·67	30		12 49·34	29·98	33
8	10 38·40			28	13 46·89		
	10 38·20				13 47·23		
	10 38·26	22·94	33		13 46·65	43·62	42
9	10 5·33			30	12 51·10		
	10 5·53				12 50·73		
	10 5·36	28·02	31		12 51·08	30·52	40
10	9 43·25			Nov. 1	13 14·28	18·58	27
	9 43·23			24	11 55·90	34·54	24
	9 43·05			Dec. 25	11 56·56		
	9 43·11	+37·95	34		11 56·34		
April 7	9 35·82				11 56·42		
	9 36·16				11 56·45	+30·54	42

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Moon's First Limb at Madras and Cambridge (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1838.	m s	s		1839.	m s	s	
Dec. 28	14 15·27			Oct. 16	12 18·51		
	14 14·94	+31·53	50		12 18·49		
1839.							
Feb. 21	14 2·89	40·54	49		12 18·47	+30·15	38
				1840.			
23	13 37·66			Feb. 12	14 56·22		
	13 37·51				14 56·43		
	13 37·86	30·59	48		14 56·34	41·07	46
25	11 54·66			13	14 50·82	34·59	30
	11 54·16			14	14 10·04		
	11 54·33				14 10·22	44·74	36
	11 54·36	27·75	42	Mar. 13	13 11·93		
26	11 2·23				13 12·28	29·34	34
	11 2·49	33·34	28	April 10	12 24·11		
27	10 20·60				12 24·21	29·92	31
	10 20·75			11	11 26·48		
	10 20·38				11 26·40		
	10 20·51	36·85	36		11 26·38	34·37	35
Mar. 24	12 8·07			13	10 16·92		
	12 7·99				10 16·94		
	12 8·09	47·94	37		10 17·03	18·80	32
25	11 11·21			15	10 11·50		
	11 11·18				10 11·24		
	11 11·13				10 11·61		
	11 11·15	23·81	40		10 11·53	25·27	36
27	9 54·32			Oct. 7	10 54·17		
	9 54·28				10 54·09	33·86	28
	9 54·35	24·90	31	9	11 8·63		
April 25	9 31·93				11 8·57		
	9 31·77				11 8·66	19·96	34
	9 31·80	20·57	30	Dec. 3	10 42·63	25·70	22
28	10 32·76			6	13 33·42		
	10 32·90	32·27	27		13 33·62	+24·26	34
				1842.			
May 21	9 49·82	+32·04	20	Feb. 21	14 31·42		

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Moon's First Limb at Madras and Cambridge (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1842.	m s	s		1843.	m s	s	
Feb. 21	14 31·83	+40·80	37	April 12	12 45·36		
May 17	12 4·50	23·68	24		12 45·24	+34·80	32
June 20	13 17·00	16·90	27	May 13	14 28·64		
21	13 16·71	24·37	27		14 28·67		
July 20	12 24·12	35·39	25		14 28·64		
Aug. 15	12 56·83				14 28·66	37·09	50
	12 57·07			June 6	12 3·39	34·70	24
	12 57·06			10	14 24·47		
	12 56·82	36·44	45		14 24·62	37·77	36
16	12 29·53	39·88	25	Aug. 8	12 4·56	28·47	24
Sep. 14	11 23·53			Sep. 4	12 8·94	32·77	24
	11 23·34	37·29	29	Oct. 2	11 36·16		
15	10 45·16	31·72	22		11 36·33	32·09	30
16	10 14·93			4	10 27·25		
	10 15·22	33·24	26		10 27·21	35·75	27
Oct. 13	10 25·39			5	10 10·10	39·00	20
	10 25·55			Nov. 3	10 5·12	37·05	20
	10 25·43	35·47	32	4	10 17·48	37·90	27
Nov. 12	9 49·02			6	11 5·31	45·52	22
	9 48·79	51·16	25	28	10 31·57		
17	12 21·11				10 31·51	26·23	27
	12 21·20			29	10 11·78		
	12 21·15	23·66	38		10 11·72		
Dec. 14	12 2·82				10 11·55	35·00	32
	12 2·93			1844. Feb. 1	12 32·19		
	12 3·15	38·42	37		12 32·27		
17	13 49·10				12 32·23	37·19	39
	13 49·52	41·80	34	Mar. 1	12 15·63		
1843. Feb. 10	13 36·07				12 15·48	37·06	31
	13 36·01	35·41	34	2	12 10·13		
13	13 14·91				12 10·14	+33·39	31
	13 14·99	+37·55	34	28	11 59·79		

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***Moon's First Limb at Madras and Cambridge* (*continued*).**

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1844.	m s	s		1844.	m s	s	
Mar. 28	11 59·91			April 30	13 6·68	+30·00	33
	11 59·77	+32·59	37	May 1	13 55·03		
29	11 56·75				13 55·16	31·71	35
	11 56·62			July 27	14 10·13		
	11 56·59				14 10·19		
	11 56·65	35·12	42		14 10·02	38·56	44
30	11 57·48			Sep. 21	12 42·77		
	11 57·56				12 43·14	40·34	32
	11 57·76			24	11 9·43		
	11 57·53	36·19	42		11 9·37		
April 1	12 24·91				11 9·69		
	12 25·02				11 9·55	41·24	39
	12 24·87			25	10 56·94		
	12 25·12	33·92	43		10 57·14		
2	12 54·12				10 57·14	38·80	37
	12 54·36	33·54	33	Nov. 20	10 43·34		
29	12 25·48				10 43·38	37·83	27
	12 25·50			21	10 52·20	32·90	22
	12 25·51			23	11 22·93	32·27	23
	12 25·57	+33·42	43	Dec. 21	11 29·51	+24·84	23
30	13 6·60						

Moon's Second Limb at Madras and Cambridge.

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1831.	m s	s		1833.	m s		
Sep. 22	12 15·65			May 3	12 10·81		
	12 15·52	+38·42	31		12 10·87	+37·27	31
1832.				1838.			
Feb. 23	11 17·86	46·83	23	Feb. 9	10 28·62		
1833.							
Feb. 4	14 31·03	+37·73	30		10 28·66	+30·11	27

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Moon's Second Limb at Madras and Cambridge (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\,20^m$.	Weight.
1838.	m s	s		1843.	m s	s	
Mar. 11	9 33·91	+40·94	19	Feb. 15	12 40·23	+34·70	32
May 9	11 50·42	34·60	24	Mar. 17	13 22·37	28·29	27
Sep. 4	12 23·88			May 13	14 29·24		
	12 24·12	30·18	31		14 29·27		
1839.					14 29·24		
Feb. 27	10 20·29				14 29·26	39·27	50
	10 20·44						
	10 20·07			Nov. 7	11 33·22		
	10 20·20	50·81	36		11 33·16	30·15	30
28	9 51·40	34·94	20	8	11 57·36		
April 28	10 34·07				11 57·39		
	10 34·21	46·19	27		11 57·29	38·52	37
Sep. 23	12 11·03			1844.			
	12 11·15	42·09	31	Jan. 5	12 24·97		
1840.					12 24·92	25·17	31
Feb. 17	11 14·04			Mar. 5	12 29·82	33·64	25
	11 14·15	21·54	29	6	12 54·22		
1842.					12 54·52		
May 24	13 32·01				12 54·29	36·27	40
	13 31·69	35·93	34	April 3	13 31·11		
Oct. 19	11 4·02				13 31·24		
	11 4·27	44·59	28		13 31·43		
Nov. 18	13 2·89				13 31·48	21·91	48
	13 2·86			May 2	14 40·37	35·24	30
	13 2·87	42·23	40	Sep. 28	11 9·08		
1843.					11 9·02		
Feb. 14	12 53·66				11 9·10	48·15	34
	12 53·97						
	12 54·07			Nov. 26	11 41·75		
	12 54·06	+39·58	45		11 41·70	+33·24	30
15	12 40·09						

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Moon's First Limb at Madras and Edinburgh.

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 33^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 33^m$.	Weight.
1838.	m s	s		1838.	m s	s	
Jan. 4	11 59·27			May 5	9 59·04		
	11 59·44				9 58·96	+39·64	26
	11 59·62	+47·69	37	6	10 11·19		
5	12 26·28				10 11·16		
	12 26·53				10 11·49	43·96	31
	12 26·54			7	10 39·36		
	12 26·36	42·26	43		10 39·37	45·77	27
6	13 0·21			June 3	10 25·04		
	13 0·26	51·67	33		10 24·83	57·22	27
8	13 41·46			July 31	12 55·79		
	13 41·63				12 55·83	64·48	40
	13 41·53	43·19	42	Aug. 3	15 19·34		
Mar. 8	11 4·40				15 19·34	45·56	39
	11 4·32	22·18	28	Sep. 29	13 54·36		
9	10 29·80				13 54·21		
	10 29·98				13 54·53	57·57	43
	10 29·93	21·72	32	Oct. 1	12 59·55		
April 2	12 57·54				12 59·27		
	12 57·93				12 59·38		
	12 57·82	39·18	40		12 59·37	36·64	45
3	12 7·46	45·95	24	Nov. 1	13 47·50	49·37	28
5	10 39·58	31·42	22	Dec. 25	12 26·19		
6	10 12·72				12 26·11		
	10 12·76				12 26·17	53·03	38
	10 12·80			26	13 10·83		
	10 12·94	33·91	36		13 10·81	60·43	34
8	10 1·65			29	15 10·77	35·79	31
	10 1·62			1839. Jan. 26	14 44·56		
	10 1·49				14 44·57	+37·01	37
	10 1·74	+49·31	35	Feb. 22	14 38·83		

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Moon's First Limb at Madras and Edinburgh (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 33^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 33^m$.	Weight.
1839.	m s	s		1839.	m s	s	
Feb. 22	14 38·73			Mar. 23	13 39·40		
	14 38·91				13 39·13		
	14 38·94	+37·52	51		13 39·15	+36·94	42
23	14 11·09			24	12 37·45		
	14 10·89				12 37·64		
	14 11·26	53·44	44		12 37·79	42·23	39
24	13 21·57			25	11 38·83		
	13 21·78				11 38·74		
	13 21·68				11 38·73		
	13 21·51	28·38	47		11 38·84	28·92	41
25	12 23·36			29	9 58·19		
	12 23·40				9 58·29		
	12 23·31	19·51	38		9 58·24		
26	11 29·10	23·49	23		9 58·41	44·77	35
27	10 45·85			April 26	10 2·75		
	10 46·24				10 2·84	26·08	26
	10 45·71			27	10 24·63	41·35	21
	10 45·77	37·71	37	Oct. 17	12 28·87	51·08	25
Mar. 22	14 31·33			18	12 14·20	+54·06	25
	14 31·25	+39·42	37				

Moon's Second Limb at Madras and Edinburgh.

Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 33^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $5^h\ 33^m$.	Weight.
1838.	m s	s		1839.	m s	s	
Feb. 9	10 53·97			Feb. 28	10 15·06	+21·81	21
	10 54·05	+23·13	28	Mar. 30	10 9·58	42·22	20
Dec. 1	15 21·06			Sep. 23	12 40·51	+36·27	26
	15 21·65	+44·77	39				

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Moon's First Limb at Madras and Hamburg.

Date.	Observed Values of $(t-\tau)$.	Longitude $4^h\,40^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $4^h\,40^m$.	Weight.
1838.	m s	s		1839.	m s	s	
May 5	8 24·33			Mar. 24	10 38·78		
	8 24·55				10 39·17	+59·61	31
	8 24·56	+63·95	30	25	9 48·99		
6	8 34·48				9 48·95		
	8 34·72	62·99	26		9 48·91		
7	8 57·67	49·87	21		9 48·99	53·80	40
June 2	8 27·51			26	9 9·48		
	8 27·68	73·52	25		9 9·11		
Sep. 3	11 15·05				9 9·54		
	11 15·08	60·83	33		9 9·20	59·12	36
27	12 12·98			April 28	9 14·20		
	12 12·84				9 14·49	60·92	27
	12 12·98	70·68	43	June 21	8 54·52	43·41	21
29	11 43·20			1840.			
	11 43·14			Jan. 14	12 22·46	53·67	28
	11 42·85			15	13 13·35		
	11 43·18	79·01	47		13 13·09	69·16	38
30	11 16·37			Feb. 12	13 5·58	66·93	30
	11 16·26			Mar. 15	9 56·59		
	11 16·45	60·73	40		9 56·74	50·79	29
Nov. 25	10 12·10	67·90	24	April 10	10 53·44		
27	10 27·80				10 53·52	65·33	31
	10 27·50	59·04	30	13	9 1·28		
Dec. 29	12 47·26				9 1·29		
	12 46·98				9 1·27	53·82	32
	12 47·12			15	8 56·30		
	12 46·95	58·28	51		8 55·98		
1839.					8 56·41		
Jan. 23	11 23·68	68·64	24		8 56·22	64·91	36
Feb. 21	12 18·81			June 8	8 52·33	65·32	20
	12 18·92	70·56	35	Oct. 7	9 33·62	+64·05	22
Mar. 22	12 14·32	+61·78	28	Dec. 6	11 52·52		

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Moon's First Limb at Madras and Hamburg (continued).

Date.	Observed Values of $(t-\tau)$.	Longitude, $4^h\,40^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude, $4^h\,40^m$.	Weight.
1840.	m s	s		1841.	m s	s	
Dec. 6	11 52·57	+60·86	34	Feb. 3	13 21·12		
1841.					13 21·15	+57·47	39
Jan. 2	10 56·59						
	10 56·74			4	12 38·36		
	10 56·77	78·92	39		12 38·81		
5	13 54·57	60·11	32		12 38·76	+56·15	44
Feb. 2	13 33·43	+61·81	31				

Moon's Second Limb at Madras and Hamburg.

Date.	Observed Values of $(t-\tau)$.	Longitude $4^h\,40^m$.	Weight.	Date.	Observed Values of $(t-\tau)$.	Longitude $4^h\,40^m$.	Weight.
1839.	m s	s		1840.	m s	s	
Mar. 30	8 33·33	+66·76	19	Feb. 17	9 51·78		
					9 51·88	+50·43	29

T. G. TAYLOR.

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II. *Observations of γ Virginis, accompanied by Mr. HIND'S Elements of its Orbit. By Capt. W. H. SMYTH, R.N., President of the Society.*

Read May 9, 1845.

A NEW epoch of *γ Virginis* for this apparition may be interesting to such of the Fellows of the Society as are following up the orbit of that remarkable system, which promises comparatively to be to double stars what HALLEY'S comet is among that class of bodies. The observations were made in Dr. LEE'S Observatory, at Hartwell House, with my former instruments, which are always most obligingly kept in readiness for my immediate use. The mean micrometrical readings gave 174° 36′·6 for the position, which, corrected to the meridian, and brought to proportional results, afford

Position, 185° 23′·3 (*w* 6); Distance, 2″·10 (*w* 4); Epoch, 1845·34.

The measures made on the 2d and 3d instant merit considerable confidence; for, previously to my placing the micrometer on the object, it was steadily viewed in an unilluminated field with a negative eye-piece magnifying 240 times, under which the minute companion following nearly on the parallel was distinctly seen. On this occasion, the wire-micrometer was under a positive eye-piece of 340 times during three sets of the measures, and once under one of 600; and the rock-crystal was applied with its power of 145, doubled by the interposition of the achromatic lens described in my "Cycle."

W. H. SMYTH.

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*Micrometrical Measures of γ Virginis.**

Index No. for Reference.	Designation of Star.	Right Ascension, 1845.	N. P. D. 1845.	Position with Meridian from N. by W.	Weight attributed.	Distance.	Weight attributed.	Magnitudes.	Date of Observation.
		h m	° ′	° ′		″			
1	γ Virginis	12 33	90 34	185 0	7	2·0	1	4 4	1845·33
2	....	....	....	185 26	36	2·38	13	4 4·5	1845·34
3	....	....	....	185 33	41	2·16	20	4 4·5	1845·34
4	....	....	....	186 2	15	..	..	4 4	1845·34
5	....	....	....	185 10	40	1·94	19	4 4	1845·34
6	....	....	....	185 27	12	2·0	12	4 4·5	1845·34

NOTES.

1. A very bad night; but the star was caught tolerably well at intervals. The little follower not seen. It clouded over before any distances could be taken, the 2″ is therefore only an estimation. This evening is not included in the mean epoch. Power 340.

2. A very fine night; the small *comes* in sight. A and B point upon a distant bright star on the south vertical; and the companion in the *n f* is steadily seen. The telescope in good working order. Power 340.

3. Power 340. The night continues very fine, and the *comes* flits on the following parallel in the unilluminated field. Applied a power of 600; but it proved to be too much, as the stars twirled greatly.

4. Power 145. Before closing the shutters, the crystal was applied in order to detect any possible bias. The power 145 was doubled by the interposition of the achromatic lens. These angles are not included in the mean epoch.

5. The night tolerably fine, but the *comes* is only occasionally in sight. Power 340.

6. As the night continued fine, I tried the eye-piece 600; but it was rather too much, and occasioned the stars to dance and twirl: still they were caught pretty well.

* These are the mean results of each evening, tabulated from the original observations now in the Society's archives.—(*Sec. R. A. S.*)

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Proportional Mean of the four Sets of Measures on the 2d and 3d of May.

Date. t.	Angle. $\angle$.	Weight. w.	$w.(\angle - 185°)$.	$w.(t-1845)$.	Dist. Δ.	w.	$w.\Delta$.
1845·33	185° 26′	36	+ 936	1188	2″·35	13	3055
·33	33	41	1353	1353	2·16	20	4320
·34	10	40	400	1360	1·94	19	3686
1845·34	185 27	12	324	408	2·00	12	2400
		129	+3013	4309		64	13461

Sum of $(\angle s.w)$, $\therefore$ sum of w = 185° 23′·36 $(w.6)$
Sum of $(\Delta.w)$, $\therefore$ sum of w = 2″·10 $(w.4)$
Sum of $(w.t)$, $\therefore$ sum of w = 1845·334 epoch.

Elements of the Binary Star γ Virginis. By J. R. HIND, Esq. F.R.A.S.

Communicated by him to Capt. W. H. SMYTH, in a letter dated July 7th, 1845.

Peribelion passage 1836·228.

Perihelion on the Orbit..... 319° 46′·1
Node..... 78 28·4
Inclination..... 25 14·1

Eccentricity 0·85661 $\therefore \varphi$ = 58° 56′·3

Mean Annual Motion — 152′·871

Period 141ym·297.

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For the calculation of the angles of position in this orbit, we have:—

$$u - [3{\cdot}46905] \cdot \sin u = [2{\cdot}18433]\,(1836{\cdot}228 - t)$$
$$\tan \tfrac{1}{2} v = [0{\cdot}55609] \cdot \tan \tfrac{1}{2} u$$
$$\tan (\theta - 78^\circ\ 28'{\cdot}4) = [9{\cdot}95644] \tan (v - 118^\circ\ 42'{\cdot}3)$$

u being expressed in minutes.

The epochs employed and the errors of my elements are as follows:—

		θ observed.	Comp. − observed.
		° ′	′
Herschel I.	1781·89	130 44	−4·8
——	1803·20	120 19	−1·7
Herschel II. and South	1822·25	103 24	+3·5
Dawes	1831·33	78 15	+8·8
Captain Smyth	1838·28	235 42	+9·8
——	1845·34	185 23·3	−5·6

The sums of the squares of the errors in my orbit = 243·0
In Mr. Henderson's orbit = 589·0

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III. *On the Reduction of the Observations of Distance of the Great Comet of 1843 from known Stars, which were communicated to the Society in the Years 1843 and 1844. By the Rev. R. Main, M.A., one of the Secretaries of the Society.*

Read January 9, 1846.

Perhaps there is no single feature which is more characteristic of the activity with which practical astronomy has been cultivated within the last few years, than the attention which has been bestowed upon the cometary department of it. The fifth and sixth volumes of the *Monthly Notices* of this Society contain announcements of the discovery of fourteen comets, and the number of communications to this Society, of which these bodies are the subject, since the beginning of the year 1840, amounts to very nearly 140. The greater number of these, as is well known, are telescopic, and they bear evidence, not only to the zeal of their respective discoverers, but also to that of the observers and computers, both public and private, who have, at home as well as abroad, spared no labour that the orbit of each might be as perfect as the most refined instrumental means and methods employed could render it. But telescopic comets admit of accurate observation by the comparatively small number of astronomers who possess instruments of considerable power, and observations of these must be looked for chiefly in established observatories. We have, however, in the interval of time above mentioned, had visits from three which were visible with the naked eye, viz., the Great Comet of 1843; that of 1844–45, known as Wilmot's comet; and that seen in June of 1845, which is known as Colla's comet. These, of course, were capable of being observed by instruments of the very smallest optical power, and by any persons who were capable of defining the position of a body in the heavens by any admissible means. And it is interesting to find that the opportunities thus presented were eagerly embraced by amateur astronomers who had no refined instrumental

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means at their disposal, and especially by intelligent naval officers, who made good use of the sextant, the chief instrument employed iu their profession. Indeed, in the case of the Great Comet of 1843, which is the subject of the present paper, the number of communications which poured in upon us from every quarter of the globe was so great that the mere duty of classifying, and arranging, and preparing for publication in the *Monthly Notices* the mass of interesting matter thus presented to us, formed no inconsiderable addition to the labours of the secretaries. I became, therefore, anxious that our *Monthly Notices* should contain a good and authentic record of whatever was best worth preserving in these communications, and especially that no observation of the least value, or which would be of any use in perfecting the orbit of this and all other such bodies, should be omitted.

For this, two distinct reasons might be given: first, that the value of many of these communications depended on their immediate and extensive circulation; and, secondly, that if they were deferred for the purpose of publication in our *Memoirs*, when the interest attached to them had in a great measure subsided, there would be danger of many really valuable facts being totally lost or suppressed through the difficulty of selecting what was most worthy of publication out of the accumulated mass of papers submitted to scrutiny.

It may be thought by some persons that the subject of comets has occupied too much of the attention of astronomers in general, and of this Society in particular, to the detriment of other branches of the science equally deserving; and this charge would be serious and deserving of attention if any other branch had been neglected, or even if we had been instrumental in drawing an undue attention to this to the neglect of other branches. Now, with the exception of the routine and standard work of fixed observatories, the great subject for those who would be usefully employed is connected with the phenomena of sidereal astronomy, and particularly with the observations of double stars, and I am sure that, with the Bedford Catalogue before our eyes, we shall not be likely to advance any charge of neglect against this department of astronomy. In fact, there is here no question of exciting attention to a particular branch of knowledge. Comets have been observed in a rich abundance that should call for our gratitude; communications are forwarded to us, and that which remains for us to do is to take care in honestly fulfilling the purposes of our Institution, that the materials thus collected shall be made the best possible use of for the advancement of science. So

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fully sensible have the Council been within the last year of the value of this principle as applied to the importance which is now necessarily attached to cometary observations, that a committee has been appointed, and instructions are on the eve of being published recommending the best-known and most efficient methods of observing these bodies under different circumstances. But it is not sufficient for us to be mere collectors of observations; it is necessary that we provide for their being made available for use; and with regard to observations forwarded to us which have been made at fixed observatories, they are generally reduced to that state in which they are needed; the comet's position referred to the equator is generally given, and if, as is too often the case, information respecting certain points is needed by the computer, reference can generally be made to the author. But with regard to other observations, and especially to those made with the sextant, a great amount of labour is necessary before they can be made of any use whatever, and it frequently happens that those who are perfectly competent to make this class of observations well are totally inadequate to the task of reducing them. And even if results are given from the observations, a great deal of detail and explanation would be necessary before the astronomer would place sufficient reliance on them to induce him to use them for further operations.

Now, a great mass of observations of the distances of the comet from bright stars had been collected in our *Monthly Notices*, which were chiefly made by naval officers who were well accustomed to the use of the sextant, and which therefore offered a reasonable guarantee of their correctness. Some of them also were made very soon after the perihelion passage of the comet, and long before the earliest European observations, and might therefore prove very useful. It appeared, therefore, that here was a case presented in which the Society was called upon to do something towards the reduction of the observations, and it was with this view that I submitted to the Council, in January 1844, the propriety of its being undertaken, offering, if I were allowed a computer, to take upon myself the sole charge of superintending the work. My proposition was immediately acceded to; a committee, consisting of Mr. Galloway, Mr. Stratford, and myself, was appointed; and, after the preliminary arrangements were made, the work was put into the hands of Mr. Harris, our late lamented and talented assistant-secretary, by whom it has been completed.

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I am sure that I shall be pardoned if, under the impression of the melancholy interest which the subject derives from our recent loss of this gentleman's valuable services, I dwell for a few moments on this part of my subject. The members are sufficiently aware of his talents, his more than ordinary accuracy of mind, and his unwearied attention to the best interests of the Society, to take for granted that a work of this kind when undertaken by him would be done well; and it would be, indeed, injustice to his memory to consider him in the light of the mere computer employed to perform the numerical computations after they were prepared for him. Indeed, a mere computer could not have done this, since, as might be expected in so large a mass of observations collected from so many different sources, frequent errors to a large amount occurred, which were not only perplexing to the judgment as requiring conjectural alterations, but wearisome and harassing as involving the necessity of the repetition of long and laborious calculations, with still the risk of a fresh alteration being necessary. There were also omissions of essential elements sometimes necessary to be filled up, and requiring an especial exercise of the judgment; and this was done in every case that needed it with a sagacity that calls for my own unlimited praise. Again, with regard to the accuracy with which the work was done, it will be sufficient to say that, after the correction of the distances for refraction and parallax, of itself a very troublesome and laborious work, the result of a very minute examination by myself chiefly of the remainder,* involving the solution of several hundred spherical triangles with seven-figure logarithms, was the detection of about half-a-dozen errors. It is but justice, therefore, to the memory of Mr. Harris to consider him rather in the light of a coadjutor to me in this work than of a computer, and a coadjutor who took by far the most onerous part of the duty.

I shall now proceed to give an account of the observations which have been reduced, and an explanation of the method employed in their reduction.

With respect to the observations, the following synoptical table will give the chief information that is required :—

* I would here express my thanks to Mr. Glaisher and Mr. E. Dunkin, of the Royal Observatory, for their assistance afforded me in the examination.

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Observer.	Place of Observation.	Volume and Page of Monthly Notice.	No. of Obs.	Remarks.
Mr. BELAM	St. Domingo	Vol. V. p. 294	3	Long. and lat. given by the author.
Mr. POLLOCK	At Sea	Vol. V. p. 296	5	Ditto.
Mr. BAMBER	Demerara.....	Vol. V. p. 299	11	Long. and lat. from RAPER's Navigation.
Capt. GEALE	Demerara.....	Vol. V. p. 307	22	Ditto.
Capt. TUCKER	At Sea	Vol. VI. p. 3	39	Long. and lat. given by author.
Lieut. KAY	Van Dieman's Land	Vol. VI. p. 6	37	Long. and lat. taken from Phil. Trans. for 1843, p. 169.
Mr. BURDWOOD ..	At Sea	Vol. VI. p. 22	1	Long. and lat. given approximately.
Mr. MACLEAN	Cape Coast Castle.	Vol. VI. p. 77	16	Long. and lat. from RAPER.
Capt. P. P. KING.	Port Stephen.....	.....	4	Long. and lat. given by author.

The above table needs little explanation; the different columns contain respectively the name and station of the observer, the volume and page of the *Monthly Notices* at which the observations are to be found, the number of observations requiring reduction, and, finally, the authorities for the longitudes and the latitudes which are used in the reductions. The number of observations recorded above is the smallest number that can be made in the different groups of observations, by combining each measured distance with that which follows it; but the number of combinations employed so as to give the best possible result is much greater than this, and the total number of such observations actually reduced is 199.

The different steps of the computations, according to the instructions which I delivered to Mr. HARRIS, are as follows:—

1. A table was to be made of the places of the stars of comparison, embracing every day of observation.
2. The sidereal times and the Greenwich mean solar times of all the observations were to be computed.
3. An approximate ephemeris was to be constructed for the comet, containing the horizontal parallaxes.
4. Approximate zenith distances were to be computed for each object observed.
5. The observed distances were to be corrected for refraction and parallax.
6. The right ascensions and north polar distances of the comet were then to be deduced from the corrected distances.

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I shall treat of these in their order :—

1. The places of the stars were taken from the *Nautical Almanac* without alteration, excepting in the case of *γ Orionis*, which was brought up from the Astronomical Society's Catalogue, no greater accuracy being needed. Their apparent places for the days of observation were given in a table included amongst the computations.

2. In computing the sidereal times of observation, the longitudes used were either those supplied by the author, if at sea, or, if the observations were made at any known station, the best authority was used, but principally RAPER's Table of Longitudes and Latitudes.

The rule is, "to the sidereal time at preceding Greenwich mean noon add the mean time at place, and the acceleration for the approximately known Greenwich mean solar hour and minute at the time of observation."

3. Mr. HARRIS constructed with considerable labour an ephemeris from elements computed by himself. It was found difficult to get observations near the perihelion passage to supply even the rough places which were requisite as arguments, and his zeal in undertaking this part of the labour, which was necessary, though at first sight it seems disproportionate to its object, should be duly appreciated.

4. Approximate zenith distances were computed by the formula—

$$\cos \text{Z. D.} = \cos \text{hour-angle} \times \sin \text{colat} \times \sin \text{P. D.} + \cos \text{colat} \times \cos \text{P. D.}$$

without any modification, as this method I believe to involve as little computation, where great accuracy is not required, as any other, if not less. Though each individual computation of this class was easy, yet in such a mass of reductions, the amount of labour was very considerable. The whole of the work up to this stage has been minutely examined by myself.

5. The corrections for refraction and parallax will require a little more detail.

Let Z be the apparent zenith distance of the comet,

z the apparent zenith distance of the star,

d the observed distance of the comet from the star as affected by refraction and parallax.

$Z + \delta Z$, $z + \delta z$, and $d + \delta d$, the true values of the same quantities cleared of refraction and parallax.

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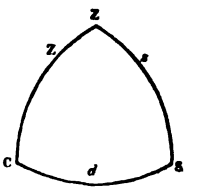
Then, in the accompanying spherical triangle,



$$\cos \mathrm{C\,Z\,S} = \frac{\cos d - \cos \mathrm{Z} \cos z}{\sin \mathrm{Z} \sin z},$$

and since the angle C Z S is not affected by refraction and parallax, we get by differentiation,

$$0 = \sin \mathrm{Z} \sin z \{\sin \mathrm{Z} \cos z \delta \mathrm{Z} + \cos \mathrm{Z} \sin z \delta z - \sin d \delta d\}$$
$$-(\cos d - \cos \mathrm{Z} \cos z) \{\cos \mathrm{Z} \sin z \delta \mathrm{Z} + \sin \mathrm{Z} \cos z \delta z\}$$

or
$$\sin \mathrm{Z} \sin z \sin d \delta d = \left.\begin{aligned} &\sin^2 \mathrm{Z} \sin z \cos z \delta \mathrm{Z} \\ &+ \cos^2 \mathrm{Z} \sin z \cos z \delta \mathrm{Z} \end{aligned}\right\}$$
$$\left.\begin{aligned} &+ \sin^2 z \sin \mathrm{Z} \cos \mathrm{Z} \delta z \\ &+ \cos^2 z \sin \mathrm{Z} \cos \mathrm{Z} \delta z \end{aligned}\right\}$$
$$- \cos d \{\cos \mathrm{Z} \sin z \delta \mathrm{Z} + \sin \mathrm{Z} \cos z \delta z\}$$
$$= \sin z \cos z \delta \mathrm{Z} + \sin \mathrm{Z} \cos \mathrm{Z} \delta z$$
$$- \cos d \{\cos \mathrm{Z} \sin z \delta \mathrm{Z} + \sin \mathrm{Z} \cos z \delta z\}$$

and, dividing out by sin Z sin z, we get

$$\sin d \times \delta d = \frac{\cos z}{\sin \mathrm{Z}} \delta \mathrm{Z} + \frac{\cos \mathrm{Z}}{\sin z} \delta z$$
$$- \cos d \left\{\frac{\cos \mathrm{Z}}{\sin \mathrm{Z}} \delta \mathrm{Z} + \frac{\cos z}{\sin z} \delta z\right\}$$

Now, let Π = comet's horizontal parallax,

then $\quad \delta \mathrm{Z} = \alpha_0 \tan \mathrm{Z} - \Pi \sin \mathrm{Z}$

and $\quad \delta z = \alpha_1 \tan z$

where α_0 and α_1 for low objects are obtained from Bessel's Refraction Tables, being themselves functions of the zenith distances; therefore,

$$\sin d \times \delta d = \alpha_0 \frac{\cos z}{\cos \mathrm{Z}} + \alpha_1 \frac{\cos \mathrm{Z}}{\cos z}$$
$$- \cos d \{\alpha_0 + \alpha_1\}$$
$$- \Pi \{\cos z - \cos d \cos \mathrm{Z}\}$$
$$= \{\alpha_0 - \Pi \cos \mathrm{Z}\} \left\{\frac{\cos z}{\cos \mathrm{Z}} - \cos d\right\} + \alpha_1 \left\{\frac{\cos \mathrm{Z}}{\cos z} - \cos d\right\}$$

from which formula, δd, or the correction of the distance, is obtained in a

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shape very well adapted for use, and its application gives very little more trouble than the computation of a vertical refraction, the values of $\frac{\cos z}{\cos Z}$ and its reciprocal being obtained while computing z and Z.

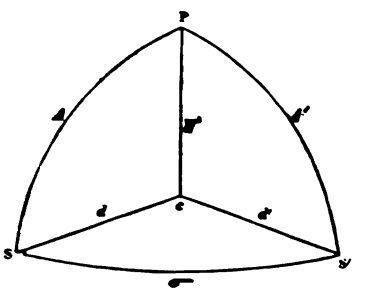
One great deficiency in the accurate computation of the above correction was found to exist in the want of recorded values of the barometer and thermometer readings in the greater part of the observations, an omission which can only be accounted for in the case of intelligent officers by supposing that these instruments were not at hand. An attempt has been made to render this omission as slightly injurious as possible, by getting, when practicable, the mean pressure and temperature for the particular time and climate under consideration. For the Demerara observations these have been taken from Schomburgh's *Description of British Guiana*. For Mr. Belam's observations, the barometer reading has been assumed to be $29^{in}\cdot96$, and for Capt. Tucker's $30^{in}\cdot00$, and in each of these cases it has been assumed that the temperature varies as the cosine of the latitude. For Mr. Burdwood's and Mr. Maclean's observations, $29^{in}\cdot8$ and 82° have been assumed to be the barometer and thermometer readings. Finally, for the computation of the values of α_e and α_s, Mr. Sheepshanks' compendious Tables were used for zenith distances less than 77°, and Bessel's Tables for greater zenith distances.

6. The corrections thus computed having been applied to the observed distances, the remaining steps were included in the solution of the spherical triangles requisite for the deduction of the right ascension and north polar distance of the comet. But before proceeding to this, that nothing might be wanting to the theoretical solution of the problem, I proceeded with the following investigation of the expression for the north polar distance in terms of the north polar distances of the stars of comparison, their distance from each other, and the observed distances from the comet.

Let Δ and Δ' be the polar distances of the stars, and σ their distance;

d and d' the observed distances from the comet;

π the polar distance of comet.



Then, if the comet be within the triangle formed by joining the stars with each other and the pole by arcs of great

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circles, the sum of the three angles thus formed will be 360°; but, if without, the sum of two of the angles will be equal to the remaining one.

If, then, those angles be θ', θ'', and θ''',

$$\cos(\theta' + \theta'') = \cos\theta''' \text{ in both cases,}$$

or $$\cos\theta' \cos\theta'' - \sin\theta' \sin\theta'' = \cos\theta'''$$

or $$\sin\theta' \sin\theta'' = \cos\theta' \cos\theta'' - \cos\theta'''$$

and $$(1 - \cos^2\theta')(1 - \cos^2\theta'') = \cos^2\theta' \cos^2\theta'' - 2\cos\theta' \cos\theta'' \cos\theta''' + \cos^2\theta'''$$

whence $$\cos^2\theta' + \cos^2\theta'' + \cos^2\theta''' = 1 + 2\cos\theta' \cos\theta'' \cos\theta'''$$

Now $\cos\theta'$, $\cos\theta''$, and $\cos\theta'''$, are respectively expressed by

$$\frac{\cos\Delta - \cos\pi\cos d}{\sin\pi\sin d}, \quad \frac{\cos\Delta' - \cos\pi\cos d'}{\sin\pi\sin d'}, \text{ and } \frac{\cos\sigma - \cos d\cos d'}{\sin d\sin d'}$$

and, by substituting and reducing, we get

$$\sin^2 d'\{\cos\Delta - \cos\pi\cos d\}^2 + \sin^2 d\{\cos\Delta' - \cos\pi\cos d'\}^2 + \sin^2\pi\{\cos\sigma - \cos d\cos d'\}^2$$
$$= \sin^2\pi\sin^2 d\sin^2 d' + 2(\cos\Delta - \cos\pi\cos d)(\cos\Delta' - \cos\pi\cos d')(\cos\sigma - \cos d\cos d');$$

whence, by a series of reductions, which are sufficiently obvious, we get finally the following symmetrical equation:—

$$\left.\begin{array}{l}\sin^2\Delta\sin^2 d' \\ +\sin^2\Delta'\sin^2 d \\ +\sin^2\sigma\sin^2\pi\end{array}\right. + 2\left\{\begin{array}{l}\cos\Delta\cos\pi(\cos d - \cos d'\cos\sigma) \\ +\cos\Delta'\cos\pi(\cos d' - \cos d\cos\sigma) \\ +\cos d\cos d'(\cos\sigma - \cos\Delta\cos\Delta') \\ +\cos\Delta\cos\Delta'\cos\sigma\end{array}\right\} = 2,$$

a quadratic equation, which will give directly the two values of the north polar distance of the comet, corresponding to the observed distances. The only practical use which might be made of this equation for the subject under consideration is the deduction of the errors of the north polar distance of the comet in terms of the errors of the observed distances.

Again, for the direct deduction of the right ascension of the comet:—

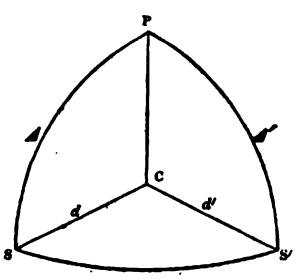
Let P be the pole of the heavens;
S, S', the stars, and C the comet.

Let also $\angle SPS'$ (= difference of R.A. of stars) $= \alpha$

$\angle SPC = x$; $\angle SCP = x'$

$\angle S'PC = y$; $\angle S'CP = y'$

$\angle SCS'$ (which is known) $= \beta$



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Then $$x' + y' = 2\pi - \beta \qquad (1)$$

and $$x + y = \alpha \qquad (2)$$

Also $$\frac{\sin x'}{\sin x} = \frac{\sin \Delta}{\sin d} \qquad (3)$$

and $$\frac{\sin y'}{\sin y} = \frac{\sin \Delta'}{\sin d'}$$

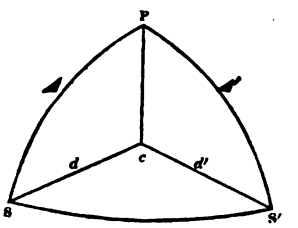
or $$-\frac{\sin(\beta + x')}{\sin(\alpha - x)} = \frac{\sin \Delta'}{\sin d'} \qquad (4)$$

or $$-\frac{\cot x' + \cot \beta}{\cot x - \cot \alpha} = \frac{\sin \Delta' \sin \alpha \sin d}{\sin d' \sin \beta \sin \Delta}.$$

Also $$\frac{1 + \cot^2 x}{1 + \cot^2 x'} = \frac{\sin^2 \Delta}{\sin^2 d};$$

and from these last equations it is easy to eliminate cot x', and the resulting quadratic equation in cot x will give the value of the difference of right ascension of the comet and the star S. I have not thought this solution of sufficient practical use to induce me to pursue it farther.

The practical solution which I have used is the following; the same figure and notation remaining:—



1. To find S S′ the distance of the stars.

Find an arc θ such that

$$\tan \theta = \cos S P S' \tan \Delta.$$

Then $$\cos S S' = \frac{\cos \Delta}{\cos \theta} \cos(\Delta' - \theta).$$

2. Find the angle P S S′ by the formula

$$\sin P S S' = \frac{\sin S P S' \sin \Delta'}{\sin S S'},$$

or, if P S S′ be near 90°, by the formula,

$$\sin \frac{P S S'}{2} = \sqrt{\frac{\sin(S - \Delta) \sin(S - S S')}{\sin \Delta \sin S S'}}, \text{ where } S = \frac{\Delta + \Delta' + S S'}{2}.$$

3. Find the angle S′ S C by the formula

$$\cos \frac{S' S C}{2} = \sqrt{\frac{\sin S' . \sin(S' - d')}{\sin d \sin S S'}}, \text{ where } S' = \frac{d + d' + S S'}{2},$$

or $$\sin \frac{S' S C}{2} = \sqrt{\frac{\sin(S' - d) \sin(S' - S S')}{\sin d \sin S S'}},$$

according to circumstances.

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4. Angle $PSC = PSS' - S'SC$, and is therefore known.

5. Let $$\tan\theta = \cos PSC \tan\Delta,$$

then $$\cos PC = \frac{\cos\Delta}{\cos\theta}\cos(\theta - d),$$

whence the north polar distance or south polar distance of the comet is found.

6. Lastly, $$\sin SPC = \sin PSC \cdot \frac{\sin d}{\sin PC},$$

or $$\sin\frac{SPC}{2} = \sqrt{\frac{\sin(S''-\Delta)\sin(S''-PC)}{\sin\Delta\sin PC}}, \left(\text{where } S'' = \frac{\Delta + d + PC}{2}\right),$$

according to circumstances, whence the difference of the right ascensions of the comet and star S is found.

The whole of the method which has been pursued in the course of the computations has now been fully explained. Whether, in reconsidering the subject myself or by submitting it to other mathematicians now the labour is completed, methods might not be found of shortening or easing some of the processes, I do not know. One thing has suggested itself to me for the benefit of persons who may hereafter undertake a similar work. I would suggest the expediency of tabulating beforehand all the trigonometrical functions which will admit of tabulation, the differences of right ascension of the stars, and other quantities which occur frequently. No labour has been thrown away in the reductions before us by repeating operations once performed; but the tabulation of the trigonometrical functions would ease the work very considerably.

Again, in the reduction of a set of observations wherein great accuracy is not required, the elements necessary for the correction of the observed distances and for other purposes, viz. the approximate right ascension, north polar distance, and zenith distance of the comet, might be obtained with tolerable precision from a celestial globe, simply by rectifying it for the place of observation, and finding on it the stars of comparison, and the points of intersection of arcs equal to the observed distances described round them as centres. The zenith distances of the stars might also be found on the globe.

The results of the computations have been drawn up according to the following form, each set of observations being discussed separately.

The columns contain the days and times of observation; the different longitudes and latitudes when the observations were made at sea; the sidereal

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time of observation; the Greenwich mean solar time of observation; the correction of the distance; the observed and corrected distances; and, finally, the deduced right ascension and north polar distance of the comet.

I have only to add that I could wish that the deduced places of the comet were more worthy of the labour used in the reductions than the results have proved them to be. For my own part, I have been much disappointed in this respect, many of the results obtained on the same evening differing so widely as to make it probable that some of the distances are still erroneous. It were to be wished that gentlemen who record observations of the nature of those in question would be particular in stating any circumstance which may affect them. For example, I will mention two elements only in the observations here treated of, which have been the source of a great deal of uneasiness to myself and Mr. Harris, viz. the time and the index correction of the sextant. We are sometimes left in uncertainty whether the time set down is chronometer time, or mean solar time at place, or Greenwich mean solar time; and with regard to the measures themselves, no pains are generally taken to inform us whether the index correction has been applied, or, if applied, we have no guarantee for its accuracy, excepting the character of the observer. Now a good observation, carrying conviction of its goodness to a competent judge, should contain all the subsidiary elements necessary for its complete reduction, so that a computer, however distant, may have the same means (or nearly so) of obtaining a good result from it as the observer himself had, taking for granted only the numbers read from the instruments. Each day's work for a set of sextant observations would include at least the observations by which the time and index corrections were obtained, as well as the measures of distance. Every reader of the volumes issued from the Observatory of Greenwich is rendered nearly as good a judge of their accuracy as the persons who made them; and this is requisite in every other class of observations, and especially where many of the circumstances are necessarily subject to so much greater uncertainty. But I consider that the systematic examination and reduction of such observations as the present have at least, in a first instance of the kind, a value independent of their accuracy.

There is a precedent for other attempts of the same kind, and an encouragement to gentlemen who may bestow their labour on another occasion by the assurance that their zeal is not misappreciated. At the same time improvements both in the method of observing and of reduction will be sug-

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gested; and in some cases the sextant may be made to play an important part in cometary observations.

As a final suggestion, which I offer with deference to the members, and especially to the Council of this Society, I would express an opinion that a search into the volumes of our *Memoirs* might present to us several classes of observations well worthy of the labour of reduction; and that the task of doing so would be quite within the province of this Society, as far as the sums which can be spared from its limited funds will permit. A standing Committee would undertake the task of selection; and I hope that our Council will always contain a sufficient number of members willing to bestow the necessary pains on the arrangement and superintendence of the calculations, to insure the carrying out of such a resolution efficiently.

Observations of the Distances of the Comet from known Stars, made by JOHN BELAM, *Esq. at Sea, in Latitude* 18° 33′ 18″ *N. and Longitude* 72° 17′ 0″ *W. of Greenwich.*

Day.	Mean Time at Ship.	Greenwich Mean Time.	Sidereal Time at Ship.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m s	h m s	h m s		° ′ ″	in.	°	′ ″	° ′ ″	h m s	° ′ ″
Mar. 7	7 5 48	11 54 56	6 5 59	Sirius	83 12 10	29·96	76·72	+5 30	83 17 40	0 51 59	102 20 33
				Canopus	75 25 40	....	....	1 51*	75 27 31		
13	7 3 38	11 52 46	6 27 28	Canopus	66 55 10	....	....	1 11	66 56 21	2 3 11	99 35 14
				Sirius	67 1 40	....	....	2 14†	67 3 54		
	7 5 38	11 54 46	6 29 28	Sirius	67 1 40	....	....	2 4	67 3 44	2 2 30	100 17 37
				Aldebaran	44 26 30	....	....	+2 12‡	44 28 42		

The nucleus of the comet was invisible, and the observer remarks that "the generative point was surrounded by a misty haze, from which cause the observations could not be taken with any great precision."

* A correction of + 8″ for the motion of the comet during the interval of observation is included in this quantity.

† A correction of + 12″ for the motion of the comet during the interval of observation is included in this quantity.

‡ A correction of + 7″ for the motion of the comet during the interval of observation is included in this quantity.

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Observations of the Distances of the Comet from known Stars, made by R. Pollock, Esq. at Sea.

Day.	Mean Time at Ship.	Greenwich Mean Time.	Sidereal Time at Ship.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Pole Distance.
1843.	h m s	h m s	h m s		° ′ ″	in.	°	′ ″	° ′ ″	h m s	° ′
Mar. 10	7 0 0	7 29 28	6 11 17	Rigel*	53 40 0	29·92	76·0	+1 54	53 41 54	1 29 0	101 53 5
				Sirius	74 33 30	....	....	6 26†	74 39 56		
	7 35 0	8 4 28	6 46 22	Sirius	74 33 30	....	....	3 38	74 37 8	1 29 8	101 55 5
				Canopus	70 6 0	....	....	3 4‡	70 9 4		
11	7 35 0	8 14 20	6 50 21	Sirius	71 41 0	29·90	78·0	3 11	71 44 11	1 42 2	101 9 2
				Canopus	68 47 0	....	....	2 24§	68 49 24		
13	7 35 0	8 30 32	6 58 16	Sirius	67 0 0	29·92	81·0	2 35	67 2 35	2 1 12	101 42
				Canopus	65 30 0	....	....	+2 17‖	65 32 17		

* In Mr. Pollock's communication this star is called *Regulus*, which is plainly an error; it is also uncertain whether the minutes of the observed distance should be 20′ or 40′; in the reduction, however, the latter has been assumed to be the correct reading. At the time of observation the ship was in latitude 14° 53′ S. and longitude 7° 22′ W. of Greenwich.

† A correction of +4′ 10″ for the motion of the comet during the interval of observation is included in this quantity.

‡ A correction of +16″ for the motion of the comet during the interval of observation is included in this quantity.

§ A correction of +16″ for the motion of the comet is included in this quantity. At the time of observation the ship was in latitude 13° 14′ S. and longitude 9° 50′ W.

‖ A correction of +27″ for the motion of the comet is included in this quantity. In Mr. Pollock's paper the observed distance of the comet from *Canopus* is 69° 30′. The ship's place is not given for the time of observation, but it is here assumed to have been in latitude 9° 5′ S. and longitude 13° 53′ W. of Greenwich.

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Observations of the Distances of the Comet from known Stars, made by JOHN BAMBER, *Esq. at Georgetown, Demerara, in Latitude* 6° 49′ 20″ *N. and Longitude* 58° 11′ 30″ *W. of Greenwich.*

Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m	h m s	h m s		° ′ ″	in.	°	′ ″	° ′ ″	h m s	° ′ ″
Mar. 18	7 23	11 24 1	7 14 40	Sirius	55 56 0	29·959	80·35	+1 46	55 57 46	2 48 55	100 13 48
				γ Orionis	40 16 7	....	....	2 3*	40 18 10		
	7 28	11 29 1	7 19 41	γ Orionis	40 16 7	....	....	1 44	40 17 51	2 46 41	98 48 51
				Aldebaran	35 11 0	....	....	2 20†	35 13 20		
19	7 11	11 9 43	7 6 37	γ Orionis	38 14 0	....	....	1 17	38 15 17	2 55 18	98 39 10
				Rigel	32 32 9	....	....	1 22‡	32 33 31		
	7 14	11 12 43	7 9 37	Rigel	32 32 9	....	....	1 12	32 33 21	2 55 14	99 12 7
				Aldebaran	34 2 0	....	....	1 11§	34 3 11		
	7 17	11 15 43	7 12 38	Aldebaran	34 2 0	....	....	1 2	34 3 2	2 53 33	98 49 11
				Sirius	55 9 0	....	....	1 59‖	55 10 59		
26	7 33	11 31 33	7 53 49	Aldebaran	26 32 0	....	....	0 40	26 32 40	3 39 39	97 38 12
				Sirius	44 25 0	....	....	+2 23¶	44 27 23		

* A correction of +26″ for the motion of the comet during the interval of observation is included in this quantity.

† A correction of +59″ for the motion of the comet during the interval of observation is included in this quantity.

‡ A correction of +14″ for the motion of the comet during the interval of observation is included in this quantity. The observation of the distance of the comet from *α Orionis* is erroneous, and is therefore rejected.

§ A correction of +10″ is included in this quantity for the motion of the comet during the interval of observation. The distance of the comet from *Aldebaran* has been altered from 32° 2′ to 34° 2′.

‖ A correction of +25″ for the motion of the comet during the interval of observation is included in this quantity.

¶ A correction of +1′ 3″ for the motion of the comet during the interval of observation is included in this quantity. The other measures of distance, on this and the following day, recorded by Mr. BAMBER, have been rejected on account of their discordances.

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Observations of the Distances of the Comet from known Stars, made by Capt. Geale, Lieut. A. G. Glascott, R.N., and James Donald, Esq. at Demerara, in Latitude 6° 49′ 20″ N., and Longitude 58° 11′ 30″ W. of Greenwich.

Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m	h m s	h m s		° ′	in.	°	′ ″	° ′ ″	h m s	° ′
Mar. 11	7 20	11 12 46	6 35 50	Rigel	50 23	29·959	80·35	+2 44	50 25 44	1 42 19	102 19
				Sirius	71 21	....	....	2 54	71 23 54	1 43 40	100 57
				Capella	72 30*	....	....	2 19	72 32 19	1 44 51	101 8
				Canopus	68 23	....	....	1 37	68 24 37	1 42 22	101 37
				Rigel	50 23	....	....	2 44	50 25 44	1 42 28	100 44
				Capella	72 30*	....	....	2 19	72 32 19		
				Sirius	71 21	....	....	2 54	71 23 54	1 43 9	101 28
				Canopus	68 23	....	....	1 37	68 24 37		
12	7 22	11 14 46	6 41 47	Rigel	47 24	29·959	80·35	2 26	47 26 26	1 54 47	99 42
				Sirius	69 0	....	....	2 38	69 2 38	1 53 27	101 2
				Canopus	67 11	....	....	1 30	67 12 30	1 54 38	100 49
				Rigel	47 24	....	....	2 26	47 26 26	1 54 35	101 24
				Aldebaran	46 40	....	....	2 14	46 42 14	1 53 28	101 1
				Sirius	69 0	....	....	2 38	69 2 38	1 52 47	101 43
				Capella	71 55	....	....	2 6	71 57 6	1 58 2	102 33
				Aldebaran	46 40	....	....	2 14	46 42 14	1 53 31	101 2
				Canopus	67 11	....	....	1 30	67 12 30	1 51 10	101 28
				Capella	71 55	....	....	2 6	71 57 6	1 54 33	102 0
				Rigel	47 24	....	....	2 26	47 26 26		
13	7 5	10 57 46	6 28 40	Canopus	65 1	29·959	80·35	1 12	65 2 12	2 5 4	101 36
				Capella	70 13	....	....	1 38	70 14 38	2 3 16	101 20
				Sirius	66 36	....	....	1 55	66 37 55	2 5 3	99 32
				Aldebaran	43 30	....	....	1 32	43 31 32	2 9 7	100 52
				Canopus	65 1	....	....	1 12	65 2 12	2 2 35	102 4
				Sirius	66 36	....	....	1 55	66 37 55		
				Capella	70 13	....	....	1 38	70 14 38	2 18 6	103 29
				Aldebaran	43 30	....	....	+1 32	43 31 32		

* The distance of the comet from *Capella* has been altered from 77° 30′ to 72° 30′.

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Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m	h m s	h m s		° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
Mar. 19	7 15	11 7 46	7 2 21	Capella	62 24	29·959	80·35	+1 13	62 25 13	2 56 42	99 32 54
				Sirius	54 14	....	....	1 25	54 15 25	2 56 33	99 41 29
				Canopus	59 17	....	....	1 0	59 18 0	2 56 59	99 37 18
				Rigel	32 6	....	....	1 6	32 7 6	2 56 59	99 34 56
				Capella	62 24	....	....	1 13	62 25 13	2 57 8	99 35 54
				Canopus	59 17	....	....	1 0	59 18 0		
				Sirius	54 14	....	....	1 25	54 15 25	2 57 1	99 13 40
				Rigel	32 6	....	....	1 6	32 7 6		
26	7 10	11 2 46	7 24 56	Sirius	44 10	29·959	80·35	1 1	44 11 1	3 40 33	97 51 35
				Capella	56 55	....	....	1 0	56 56 0	3 37 54	97 39 0
				Canopus	55 46	....	....	0 57	55 46 57	3 39 54	97 22 54
				Rigel	21 35	....	....	0 39	21 35 39	3 39 40	98 39 7
				Sirius	44 10	....	....	1 1	44 11 1	3 41 19	97 11 38
				Canopus	55 46	....	....	0 57	55 46 57		
				Capella	56 55	....	....	1 0	56 56 0	3 39 48	97 45 7
				Rigel	21 35	....	....	0 39	21 35 39		
27	7 12	11 4 46	7 30 53	Sirius	43 8	29·959	80·35	1 0	43 9 0	3 44 4	98 35 42
				Rigel	20 30	....	....	0 38	20 30 38	3 44 25	96 57 22
				Canopus	55 37	....	....	0 57	55 37 57	3 40 55	97 24 59
				Capella	56 28	....	....	0 58	56 28 58	3 45 2	97 43 43
				Sirius	43 8	....	....	1 0	43 9 0	3 46 14	96 43 26
				Canopus	55 37	....	....	0 57	55 37 57		
				Rigel	20 30	....	....	0 38	20 30 38	3 44 13	97 37 14
				Capella	56 28	....	....	0 58	56 28 58		
31	7 35	11 27 46	8 9 43	Canopus	53 28	29·959	80·35	0 54	53 28 54	4 5 41	96 45 24
				Sirius	38 31*	....	....	1 7	38 32 7	4 5 44	96 42 53
				Capella	54 11†	....	....	0 57	54 11 57	4 2 39	96 32 14
				Aldebaran	23 30	....	....	0 27	23 30 27	4 5 53	96 44 1
				Canopus	53 28	....	....	0 54	53 28 54	4 5 56	96 43 36
				Capella	54 11†	....	....	0 57	54 11 57		
				Sirius	38 31*	....	....	1 7	38 32 7	4 5 44	96 40 42
				Aldebaran	23 30	....	....	+0 27	23 30 27		

* The observed distance of the comet from *Sirius* has been altered from 58° 31′ to 38° 31′.

† The observed distance of the comet from *Capella* has been altered from 54° 41′ to 54° 11′.

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Observations of the Distances of the Comet from known Stars,

Day.	Mean Time at Ship.	Longitude West.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.
1843.	h m s	° ′	h m s	h m s		° ′ ″
Mar. 4	7 1 27	106 0	14 5 27	5 50 10	Rigel.....	72 44 0
					α Eridani*..	48 44 30
5	7 0 57	107 17	14 10 5	5 53 37	α Eridani ..	47 28 30
					Aldebaran..	66 16 0
6	7 4 49	107 59	14 16 45	6 1 26	α Eridani ..	46 26 8
					Rigel.....	65 32 45
					Sirius	85 59 0
					Aldebaran..	62 4 0
					α Eridani ..	46 26 8
					Sirius	85 59 0
					Rigel.....	65 32 45
					Aldebaran..	62 4 0
7	6 30 0	108 22	13 43 28	5 30 28	Rigel.....	61 56 15
					Aldebaran..	59 25 0
					Sirius	82 31 30
					Rigel.....	61 56 15
8	6 41 54	107 31	13 51 58	5 46 20	Sirius	79 34 0
					Rigel.....	59 3 0
	7 6 4	....	14 16 8	6 10 34	Sirius	79 33 0
					Aldebaran..	56 44 30
9	7 10 23	106 29	14 16 19	6 18 50	Sirius	76 39 15
					Rigel.....	55 49 50
10	6 52 15	106 17	13 59 23	6 4 36	Sirius	73 45 0
					Rigel.....	52 28 50
					α Eridani ..	46 17 0
					Sirius	73 45 0

* In Captain TUCKER's paper this star is called *Fomalhaut.*

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made at Sea by Capt. TUCKER, R.N. of H. M. Ship Dublin.

Latitude South.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
8 10	30·0	81·66	+6 22	72 50 22	0 10 37	101 45 55
....	....	....	1 59	48 46 29		
11 2	30·0	80·98	1 31	47 30 1	0 24 34	102 16 55
....	....	....	3 56	66 19 56		
14 1	30·0	80·04	1 13	46 27 21	0 40 2	102 37 50
....	....	....	3 42	65 36 27	0 40 4	102 30 32
....	....	....	4 3	86 3 3	0 41 34	101 13 53
....	....	....	2 55	62 6 55	0 44 0	102 28 31
....	....	....	1 13	46 27 21	0 39 54	102 38 4
....	....	....	4 3	86 3 3	0 40 34	100 42 51
....	....	....	3 42	65 36 27		
....	....	....	2 55	62 6 55		
16 44	30·0	79·01	1 51	61 58 6	0 55 7	101 55 35
....	....	....	1 28	59 26 28	0 55 25	102 3 47
....	....	....	2 12	82 33 42	0 55 1	102 24 53
....	....	....	1 51	61 58 6		
18 21	30·0	78·30	2 14	79 36 14	1 6 44	103 10 58
....	....	....	1 52	59 4 52		
....	....	....	2 56	79 35 56	1 7 50	102 7 57
....	....	....	1 51	56 46 21		
19 33	30·0	77·74	2 40	76 41 55	1 19 59	102 17 13
....	....	....	2 59	55 52 49		
20 41	30·0	77·18	2 0	73 47 0	1 34 1	100 35 33
....	....	....	1 36	52 30 26	1 33 51	101 44 31
....	....	....	0 46	46 17 46	1 32 51	101 44 28
....	....	....	+2 0	73 47 0		

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Day.	Mean Time at Ship.	Longitude West.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.
1843.	h m s	° ′	h m s	h m s		° ′ ″
Mar. 11	7 1 35	105 25	14 3 15	6 17 53	α Eridani ..	46 31 0
					Sirius	71 2 0
					Rigel.....	50 11 50
					α Eridani ..	46 31 0
12	7 15 10	105 16	14 16 14	6 35 27	Sirius	68 36 15
					Rigel.....	47 14 45
					Aldebaran..	46 31 15
					α Eridani ..	46 57 0
					Sirius	68 36 15
					Aldebaran..	46 31 15
					Rigel.....	47 14 45
					α Eridani ..	46 57 0
17	7 8 15	96 44	13 35 11	6 48 8	Sirius	57 40 0
					Rigel.....	35 36 30
					Aldebaran..	36 49 0
					α Orionis...	49 3 0
					Sirius	57 40 0
					Aldebaran..	36 49 0
					Rigel.....	35 36 30
					α Orionis...	49 3 0
18	7 14 40	95 52	13 38 8	6 58 30	Sirius	55 58 0
					Rigel.....	33 49 13
					Canopus ..	60 18 0
					Sirius	55 58 0
					α Orionis...	47 0 30
					Rigel.....	33 49 13
					Aldebaran..	35 19 0
					α Orionis...	47 0 30
					Canopus ..	60 18 0
					Aldebaran..	35 19 0
					Sirius	55 58 0

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Latitude South.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
22 4	30·0	76·46	+0 47	46 31 47	1 44 28	101 33 40
....	....	....	2 0	71 4 0	1 43 8	102 55 46
....	....	....	1 35	50 13 25	1 43 13	101 32 57
....	....	....	0 47	46 32 31		
24 1	30·0	75·36	2 1	68 38 16	1 55 18	100 53 20
....	....	....	1 34	47 16 19	1 55 16	101 21 14
....	....	....	1 0	46 32 15	1 55 4	101 16 59
....	....	....	0 47	46 57 47	1 54 55	101 16 49
....	....	....	2 1	68 38 16	1 54 57	101 14 48
....	....	....	1 0	46 32 15		
....	....	....	1 34	47 16 19	1 55 16	101 17 11
....	....	....	0 47	46 57 47		
30 45	30·0	70·90	1 26	57 41 26	2 42 50	99 5 50
....	....	....	0 58	35 37 28	2 42 45	100 6 31
....	....	....	0 36	36 49 36	2 42 26	100 1 55
....	....	....	1 0	49 4 0	2 42 7	99 48 34
....	....	....	1 26	57 41 26	2 42 0	99 55 41
....	....	....	0 36	36 49 36		
....	....	....	0 58	35 37 28	2 42 44	100 15 15
....	....	....	1 0	49 4 0		
32 0	30·0	69·96	1 26	55 59 26	2 50 5	98 55 36
....	....	....	0 57	33 50 10	2 50 2	99 31 45
....	....	....	1 27	60 19 27	2 49 23	99 38 10
....	....	....	1 26	55 59 26	2 49 54	99 6 32
....	....	....	0 58	47 1 28	2 50 3	99 13 4
....	....	....	0 57	33 50 10	2 50 1	99 45 21
....	....	....	0 34	35 19 34	2 51 13	100 1 18
....	....	....	0 58	47 1 28	2 50 24	99 28 2
....	....	....	1 27	60 19 27	2 49 52	99 37 19
....	....	....	0 34	35 19 34	2 49 24	99 36 30
....	....	....	+1 26	55 59 26		

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Day.	Mean Time at Ship.	Longitude West.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.
1843.	h m s	° ′	h m s	h m s		° ′ ″
Mar. 19	7 19 40	93 52	13 35 8	7 7 26	Sirius	54 11 0
					Rigel.....	31 57 15
					Canopus ...	59 21 0
					Sirius	54 11 0
					Aldebaran..	33 56 0
					Rigel.....	31 57 15
					α Orionis ..	45 20 45
					Aldebaran..	33 56 0
					Canopus ...	59 21 0
					α Orionis ..	45 20 45
					Sirius	54 11 0
20	7 11 30	90 5	13 11 50	7 3 8	Sirius	52 10 30
					Rigel.....	30 9 8
					α Orionis ..	43 35 0
					Sirius	52 10 30
					Aldebaran..	32 19 30
					Rigel.....	30 9 8
					Canopus ...	58 46 0
					Aldebaran..	32 19 30
					α Orionis ..	43 35 0
					Canopus ...	58 46 0
					Sirius	52 10 30
22	7 34 38	86 42	13 21 26	7 34 11	Sirius	49 31 30
					Rigel.....	26 49 53
					Canopus ...	57 27 30
					Aldebaran..	30 3 0
					Sirius	49 31 30
					Canopus ...	57 27 30
					Rigel.....	26 49 53
					Aldebaran..	30 3 0

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Latitude South.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
32 35	30·0	69·51	+1 26	54 12 26	2 57 39	98 47 25
....	....	....	0 56	31 58 11	2 57 36	99 25 39
....	....	....	1 28	59 22 28	2 56 54	99 32 48
....	....	....	1 26	54 12 26	2 57 1	99 26 28
....	....	....	0 33	33 56 33	2 57 36	99 33 58
....	....	....	0 56	31 58 11	2 57 36	99 28 54
....	....	....	0 56	45 21 41	2 57 47	99 36 32
....	....	....	0 33	33 56 33	2 57 15	99 29 39
....	....	....	1 28	59 22 8	2 57 32	99 26 40
....	....	....	0 56	45 21 41	2 57 13	99 13 38
....	....	....	1 26	54 12 26		
33 13	30·0	69·02	1 18	52 11 48	3 4 53	99 58 14
....	....	....	1 20	30 10 28	3 4 53	99 15 2
....	....	....	0 51	43 35 51	3 5 19	99 31 19
....	....	....	1 18	52 11 48	3 5 41	99 9 31
....	....	....	1 50	32 21 20	3 4 55	98 59 51
....	....	....	1 20	30 10 28	3 4 55	98 58 15
....	....	....	1 22	58 47 22	3 4 48	98 59 12
....	....	....	1 50	32 21 20	3 4 20	98 53 32
....	....	....	0 51	43 35 51	3 4 32	99 1 43
....	....	....	1 22	58 47 22	3 6 3	98 47 38
....	....	....	1 18	52 11 48		
34 24	30·0	68·07	1 28	49 32 58	3 18 41	97 18 54
....	....	....	0 54	26 50 47	3 18 26	98 26 39
....	....	....	1 33	57 29 3	3 17 51	98 31 57
....	....	....	0 32	30 3 32	3 17 26	98 27 46
....	....	....	1 28	49 32 58	3 17 17	98 37 1
....	....	....	1 33	57 29 3		
....	....	....	0 54	26 50 47	3 18 25	98 37 49
....	....	....	+0 32	30 3 32		

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Day.	Mean Time at Ship.	Longitude West.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.
1843.	h m s	° ′	h m s	h m s		° ′ ″
Mar. 26	7 15 57	82 40	12 46 37	7 31 11	Sirius	44 27 0
					Canopus ...	55 46 0
					Aldebaran..	26 24 30
					Sirius	44 27 0
					Rigel.....	21 12 23
					Canopus ...	55 46 0
					α Orionis ..	34 19 53
					Rigel.....	21 12 23
					Aldebaran..	26 24 30
					α Orionis ..	34 19 53
					Sirius	44 27 0

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Latitude South.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
32 2	30·0	69·94	+1 7	44 28 7	3 39 54	97 22 29
....	....	....	1 16	55 47 16	3 39 19	97 27 13
....	....	....	0 33	26 25 3	3 39 45	97 30 25
....	....	....	1 7	44 28 7	3 42 24	95 22 25
....	....	....	0 38	21 13 1	3 41 29	97 9 52
....	....	....	1 16	55 47 16	3 41 49	97 7 14
....	....	....	0 39	34 20 32	3 41 33	96 58 19
....	....	....	0 38	21 13 1	3 41 21	97 41 47
....	....	....	0 33	26 25 3	3 43 21	97 55 32
....	....	....	0 39	34 20 32	3 40 51	96 34 35
....	....	....	+1 7	44 28 7		

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Observations of the Distances of the Comet from known Stars, made at the Magnetical Observatory, Ross Bank, Van Dieman's Land, by Lieut. J. H. KAY, R.N., Director of the Observatory. Latitude, 42° 52′ S., Longitude, 147° 24′ E.

Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Result North P Distan
1843.	h m s	d h m s	h m s		° ′	in.	°	′ ″	° ′ ″	h m s	°
Mar. 7	7 30 0	6 21 40 24	6 27 50	Aldebaran	62 17	29·430	60·5	+1 39	62 18 39	0 41 50	101 49
				α^2 Centauri	104 49	....	....	2 49	104 51 49		
	7 36 0	6 21 46 24	6 33 51	α^2 Centauri	104 49	....	....	3 0	104 52 0	0 44 5	101 57
				Rigel	64 36	....	....	3 36	64 39 36		
	7 38 0	6 21 48 24	6 35 51	Rigel	64 36	....	....	3 43	64 39 43	0 44 11	101 35
				α Orionis..	77 31	....	....	3 7	77 34 7		
	7 40 0	6 21 50 24	6 37 52	α Orionis..	77 31	....	....	3 13	77 34 13	0 43 59	101 16
				Procyon ..	102 34	....	....	4 8	102 38 8		
	7 42 0	6 21 52 24	6 39 52	Procyon ..	102 34	....	....	4 15	102 38 15	0 44 5	102 2
				Sirius	85 9	....	....	4 56	85 13 56		
	7 44 0	6 21 54 24	6 41 52	Sirius	85 9	....	....	5 7	85 14 7	0 43 55	102 10
				Canopus..	76 43	....	....	5 29	76 48 29		
10	7 38 13	9 21 48 37	6 47 54	Aldebaran	53 24	29·498	57·0	1 5	53 25 5	1 23 32	102
				Canopus..	70 51	....	....	3 16	70 54 16		
	7 45 50	9 21 56 14	6 55 32	Aldebaran	53 26	....	....	1 9	53 27 9	1 23 26	102
				Canopus..	70 49	....	....	3 36	70 52 36		
11	7 36 1	10 21 46 25	6 49 38	Canopus..	69 9	29·890	50·0	2 55	69 11 55	1 36 44	101 4
				Aldebaran	50 28	....	....	0 57	50 28 57		
	7 44 15	10 21 54 39	6 57 54	α Eridani	46 19	....	....	1 50	46 20 50	1 40 35	101 4
				α Orionis..	64 4	....	....	1 55	64 5 55		
	7 49 50	10 22 0 14	7 3 30	α^2 Centauri	107 17	....	....	2 55	107 19 55	1 38 1	101 4
				Procyon ..	89 25	....	....	2 49	89 27 49		
	8 1 19	10 22 11 43	7 15 1	Sirius	72 46	....	....	3 45	72 49 45	1 36 45	101 5
				Castor ...	93 44	....	....	2 2	93 46 2		
	8 9 22	10 22 19 46	7 23 5	α Orionis..	64 11	....	....	2 38	64 13 38	1 39 15	100
				Canopus..	69 20	....	....	+4 39	69 24 39		

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Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m s	d h m s	h m s		° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
Mar. 12	7 44 15	11 21 54 39	7 1 50	Canopus..	67 38	29·890	54·0	+2 57	67 40 57	1 47 24	101 35 1
				Aldebaran	48 14	....	....	0 54	48 14 54		
	7 54 27	11 22 4 51	7 12 4	α Eridani	46 36	....	....	1 50	46 37 50	1 47 48	101 30 19
				α Orionis..	62 18	....	....	1 54	62 19 54		
	8 2 2	11 22 12 26	7 19 40	α^2 Centauri	108 11	....	....	3 7	108 14 7	1 47 18	101 5 41
				Procyon..	87 5	....	....	2 54	87 7 54		
	8 10 1	11 22 20 25	7 27 41	ι Argûs*..	90 54	....	....	4 24	90 58 24	1 47 48	101 22 4
				Sirius	70 15	....	....	3 47	70 18 47		
	8 19 10	11 22 29 34	7 36 51	Canopus..	67 32	....	....	4 51	67 36 51	1 48 7	101 32 10
				Pollux ...	92 45	....	....	2 17	92 47 17		
14	8 4 6	13 22 14 30	7 29 38	Aldebaran	43 41	30·182	51·0	0 47	43 41 47	2 8 59	101 6 19
				Canopus..	64 49	....	....	3 15	64 52 15		
	8 12 28	13 22 22 52	7 38 1	α Eridani	47 34	....	....	1 53	47 35 53	2 9 48	100 59 33
				α Orionis..	56 58	....	....	1 55	56 59 55		
	8 20 39	13 22 31 3	7 46 14	Rigel	43 49	....	....	2 46	43 51 46	2 9 12	100 56 0
				Sirius	65 15	....	....	3 43	65 18 43		
	8 21 36	13 22 32 0	7 47 11	Sirius	65 15	....	....	3 46	65 18 46	2 8 52	101 16 27
				Procyon..	81 51	....	....	3 6	81 54 6		
	8 22 43	13 22 33 7	7 48 18	Procyon..	81 51	....	....	3 10	81 54 10	2 8 34	100 42 2
				ι Argûs†..	88 58	....	....	4 35	89 2 35		
22	7 25 41	21 21 36 5	7 22 39	Canopus..	57 38	29·729	59·4	1 42	57 39 42	3 14 6	98 53 5
				Aldebaran	30 52	....	....	0 45	30 52 45		
	7 40 23	21 21 50 47	7 37 23	α Eridani	52 44	....	....	1 4	52 45 4	3 13 37	99 1 49
				α Orionis..	41 30	....	....	0 51	41 30 51		
	7 56 26	21 22 6 50	7 53 29	Rigel	28 1	....	....	1 9	28 2 9	3 13 34	99 3 44
				Regulus..	103 11	....	....	2 27	103 13 27		
	8 5 3	21 22 15 27	8 2 7	Procyon..	65 49	....	....	1 43	65 50 43	3 13 17	98 45 34
				Aldebaran	30 54	....	....	0 47	30 54 47		
	8 13 55	21 22 24 19	8 11 1	α Orionis..	41 28	....	....	1 4	41 29 4	3 13 22	98 47 56
				Rigel	28 4	....	....	1 26	28 5 26		
	8 20 55	21 22 31 19	8 18 2	Canopus..	57 40	....	....	2 43	57 42 43	3 12 58	98 59 58
				Sirius	50 27	....	....	+2 22	50 29 22		

* The observed distance of the comet from ι *Argûs* has been altered from 99° 54′ to 90° 54′.

† The observed distance of the comet from ι *Argûs* has been altered from 97° 58′ to 88° 58′.

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Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Pola Distance.
1843.	h m s	d h m s	h m s		° ′	in.	°	′ ″	° ′ ″	h m s	° ′
Mar. 24	7 51 20	23 22 1 44	7 56 15	α Eridani	54 20	29·825	52·8	+1 2	54 21 2	3 24 58	98 13 4
				Aldebaran	28 49	....	....	1 3	28 50 3		
	7 58 7	23 22 8 31	8 3 3	Regulus*	100 12	....	....	2 16	100 14 16	3 25 9	98 9 1
				Rigel	25 11	....	....	0 52	25 11 52		
	8 3 34	23 22 13 58	8 8 31	Rigel	25 12	....	....	0 55	25 12 55	3 25 4	98 17
				Aldebaran	28 51	....	....	1 8	28 52 8		
	8 8 5	23 22 18 29	8 13 3	Sirius	47 46	....	....	1 45	47 47 45	3 25 3	98 11 3
				α Orionis..	38 34	....	....	0 48	38 34 48		
	8 13 23	23 22 23 47	8 18 22	α Eridani	54 22	....	....	1 5	54 23 5	3 25 5	98 12
				Procyon..	62 51	....	....	1 31	62 52 31		
27	7 45 58	26 21 56 22	8 2 42	Canopus..	55 40	30·173	51·0	1 52	55 41 52	3 42 16	97 9 4
				Aldebaran	25 49	....	....	1 11	25 50 11		
	7 56 10	26 22 6 34	8 12 56	α Eridani	56 3	....	....	1 7	56 4 7	3 42 11	97 52 5
				Rigel	20 59	....	....	0 57	20 59 57		
	8 1 8	26 22 11 32	8 17 54	Regulus†	95 32	....	....	2 11	95 34 11	3 42 48	96 16 4
				Sirius	44 4	....	....	+1 46	44 5 46		

NOTES BY LIEUT. KAY.

March 7. The nucleus indistinct, and seen with difficulty in the inverting telescope of a sextant.

March 11. The nucleus free from clouds. It resembled a star of considerable magnitude when covered with a thin film of cloud and viewed through a telescope whose focus has not been adjusted to the eye of the observer. Every endeavour to resolve it into a point was unsuccessful.

March 14. A clear, cloudless evening; but the light of the full moon so brilliant, that *accurate* angular measurements were nearly impossible.

March 22. The comet much fainter in its appearance, and some difficulty experienced, in consequence, in measuring the angles.

March 24. A fine evening with a clear atmosphere; but the comet evidently becoming more indistinct. Great difficulty was experienced in seeing the nucleus at all in the inverting telescope of the sextant.

March 27. The comet much fainter in appearance, and the position of the nucleus not definable with accuracy.

* The observed distance of the comet from *Regulus* has been altered from 103° 12′ to 100° 12′.

† The observed distance of the comet from *Regulus* has been altered from 97° 32′ to 95° 32′.

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Observations of the Distances of the Comet from known Stars, made on board Her Majesty's Sloop Persian, at Sea, by J. BURDWOOD, Esq. Master, R.N. Latitude 5° 20′ N., Longitude 0° 0′.

Day.	Mean Time at Ship.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843. Mar. 7	h m s 7 10 0	h m s 7 10 0	h m s 6 9 24	Aldebaran	° ′ 60 29	in. 29·8	° 82·0	′ ″ +4 28	° ′ ″ 60 33 28	h m s 0 59 42	° ′ ″ 100 10 8
				Canopus	75 57	....	....	2 40	75 59 40	0 48 42	102 17 37
				Sirius	84 0	....	....	4 46	84 4 46	0 49 26	101 38 56
				Aldebaran	60 29	....	....	+4 28	60 33 28		

Observations of the Distances of the Comet from known Stars, made by GEORGE MACLEAN, Esq. at Cape Coast Castle, in Latitude 5° 6′ 6″ N. and Longitude 1° 13′ 42″ W. of Greenwich.

Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843. Mar. 4	h m 6 40	h m s 6 44 55	h m s 5 27 30	Sirius	° ′ 94 15	in. 29·8	° 82·0	′ ″ +4 34	° ′ ″ 94 19 34	h m s 0 6 43	° ′ ″ 100 54 25
				Aldebaran	69 45	....	....	4 27	69 49 27		
5	7 0	7 4 55	5 51 30	Sirius	90 35	....	....	6 37	90 41 37	0 20 23	102 22 38
				Aldebaran	67 12	....	....	6 29	67 18 29		
6	7 0	7 4 55	5 55 26	Sirius	87 18	....	....	4 58	87 22 58	0 34 56	102 2 37
				Aldebaran	63 51	....	....	4 45	63 55 45		
7	7 0	7 4 55	5 59 23	Sirius	83 48	....	....	4 0	83 52 0	0 49 50	102 4 49
				Aldebaran	60 36	....	....	+3 43	60 39 43		

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Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m	h m s	h m s		° ′	in.	°	° ′	° ′ ″	h m s	° ′ ″
Mar. 9	7 0	7 4 55	6 7 16	Sirius	77 37	29·8	82·0	+2 49	77 39 49	1 16 48	101 26 50
				Aldebaran	54 30	....	....	2 30	54 32 30		
10	7 0	7 4 55	6 11 13	Sirius	73 50	....	....	2 34	73 52 34	1 31 39	102 32 10
				Aldebaran	51 57	....	....	2 15	51 59 15		
17	7 0	7 4 55	6 38 48	Sirius	58 50	....	....	1 23	58 51 23	2 36 55	100 9 26
				Aldebaran	37 52	....	....	0 58	37 52 58		
18	7 0	7 4 55	6 42 45	Sirius	56 16	....	....	1 18	56 17 18	2 46 46	101 5 6
				Aldebaran	36 50	....	....	0 53	36 50 53		
19	7 10	7 14 55	6 56 43	Sirius	54 24	....	....	1 21	54 25 21	2 56 4	99 29 16
				Aldebaran	34 7	....	....	0 53	34 7 53		
22	7 5	7 9 55	7 3 32	Sirius	50 0	....	....	1 8	50 1 8	3 15 5	98 50 58
				Aldebaran	30 42	....	....	0 40	30 42 40		
23	7 0	7 4 55	7 2 28	Sirius	48 22	....	....	1 3	48 23 3	3 21 48	98 56 45
				Aldebaran	29 51	....	....	0 33	29 51 33		
26	7 0	7 4 55	7 14 17	Sirius	44 53	....	....	0 57	44 53 57	3 37 53	97 33 47
				Aldebaran	26 40	....	....	0 30	26 40 30		
27	7 0	7 4 55	7 18 14	Sirius	43 39	....	....	0 56	43 39 56	3 43 34	97 8 (
				Aldebaran	25 40	....	....	0 28	25 40 28		
28	7 0	7 4 55	7 22 11	Sirius	42 45	....	....	0 54	42 45 54	3 47 42	96 50 1(
				Aldebaran	24 59	....	....	0 27	24 59 27		
29	7 0	7 4 55	7 26 7	Sirius	40 58	....	....	0 47	40 58 47	3 55 4	96 58 3
				Aldebaran	24 28	....	....	0 22	24 28 22		
April 1	7 0	7 4 55	7 37 57	Sirius	38 8	....	....	0 49	38 8 49	4 7 57	96 17 4
				Aldebaran	22 58	....	....	0 22	22 58 22		

NOTES BY MR. MACLEAN.

March 4. This evening the whole of the comet was visible, but no nucleus could be distinguished.

March 5. Several glimpses of what appeared to be a nucleus were perceptible through the

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telescope of a theodolite; but being invisible through the telescope of the sextant, distances could not be measured with any degree of precision.

March 6. No nucleus discernible.

March 17. Nucleus very indistinct.

March 18. Hazy. The head of the comet obscured.

March 19. This night was clear and the outline of the comet very plainly marked. The bright spot or condensation in its head was distinctly perceptible even to the naked eye.

March 22. Although the sky was very clear the nucleus was with difficulty perceptible.

Observations of the Distances of the Comet from known Stars, made by Captain PHILLIP P. KING, R.N. at Port Stephens, New South Wales, in Latitude 32° 40′ 18″ S. and Longitude 151° 2′ 40″ E. of Greenwich.

Day.	Mean Time at Station.	Greenwich Mean Time.	Sidereal Time at Station.	Stars of Comparison.	Observed Distance.	Bar.	Therm.	Correction for Refraction and Parallax.	Corrected Distance.	Resulting Right Ascension.	Resulting North Polar Distance.
1843.	h m	d h m s	h m s		° ′	in.	°	′ ″	° ′ ″	h m s	° ′ ″
Mar. 4	7 25	3 21 20 49	6 10 57	Rigel	75 45	29·6	50·0	+10 19	75 55 19	23 58 16	99 3 47
				Aldebaran	71 42	....	....	6 41	71 48 41		
5	7 10	4 21 5 49	5 59 51	Sirius	92 4	29·6	50·0	5 23	92 9 23	0 14 44	101 53 25
				Aldebaran	68 20	....	....	3 0	68 23 0		
				Rigel	71 40	....	....	4 40	71 44 40	0 15 0	102 2 55
				Sirius	92 4	....	....	+ 5 23	92 9 23	0 15 11	101 31 38

NOTE BY CAPTAIN KING.

As the nucleus of the comet was not well defined in the horizon-glass of the sextant, these positions are only approximate.

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IV. *Account of the Measurement of the Astronomical Difference of Longitude on the Arc of Parallel extending from Greenwich to the Island of Valentia in the South-west of Ireland, and Comparison with the Geodetic Difference of Longitude.* *By G. B. Airy, Esq., Astronomer Royal.*

Read June 12, 1846.

For the sake of clearness, this Memoir will be divided into the following Sections:—

Section I.—Introduction, and Selection of Stations.

Section II.—Description of the route selected for the chronometers, of the subdivisions of the arc, of the method of conveying the chronometers, and of the transit-stations.

Section III.—Method of adopting instrumental errors of the transit-instruments; determination of clock-error; and method of using the stationary chronometers.

Section IV.—Transits at Greenwich, personal equations, instrumental errors, places of stars, and results for clock-error at the time of comparison with the travelling chronometers.

Section V.—Transits at Liverpool, and results for the error of the transit-clock at Liverpool.

Section VI.—Transits at Kingstown, personal equations, instrumental errors, catalogue of clock-stars, first results for clock-error, and results as amended by the comparison of stationary chronometers.

Section VII.—Transits at Valentia, personal equations, instrumental errors, clock-stars, first results for clock-errors, and results as amended by the comparison of stationary chronometers.

Section VIII.—List of travelling chronometers, method of using travelling chronometers, of combining results, and of deducing probable errors.

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Section IX.—Comparisons and Calculations for the Longitude of Liverpool, as determined with reference to Greenwich.

Section X.—Comparisons and Calculations for the Longitude of Liverpool, as determined with reference to Kingstown.

Section XI.—Comparisons and Calculations for the Longitude of Kingstown, as determined immediately with reference to Greenwich.

Section XII.—Comparisons and Calculations for the Longitude of Valentia, as determined with reference to Kingstown.

Section XIII.—Difference between Travelling Rates and Stationary Rates of Travelling Chronometers; correction of the determinations of Longitude for this difference; combination of the various Differences of Longitude; corrections for Personal Equation of Transit-Observers; and final result for Astronomical Difference of Longitude.

Section XIV.—Computation of the Geodetic Values of the Differences of Longitude upon Assumed Elements for the Figure of the Earth; comparison of the Geodetic Value with the Chronometrical Value; and final result for the value of an Arc of Parallel.

I.—*Introduction, and Selection of Stations.*

On examining the map of the British Islands, it will be seen that they are very favourably situated for the measure of an extensive arc of parallel. The extreme western points of Ireland are Dunmore Head (the extremity of the Dingle peninsula), and the Island of Valentia (which, from the facility of access to it, may be considered as a part of the mainland). These, or rather the small islands immediately beyond them, are the most westerly parts of Europe. The extreme eastern point of England is in the neighbourhood of Lowestoft, in latitude about twenty minutes of arc north of Dunmore Head. Between Dunmore Head and Lowestoft we have, therefore, an arc of considerable length, very little inclined to a parallel on the earth's surface. But if, instead of Lowestoft, we adopt Harwich as the eastern termination of the arc, we have a point in almost precisely the same latitude as Valentia. And these two stations, if we look merely to their relative situations on the map, are probably the best that can be selected. The effect, on the geodetic measure of the parallel, of an error in absolute azimuths (the most difficult part of a trigonometrical survey), is here annihilated. Both the stations are easily accessible;

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and both are so important as ports that the secondary value of the determination of their longitudes in reference to nautical purposes is considerable. The arc of parallel included between them is about 11° 40′; and this is little less than the difference of longitude (about 12° 12′) between the extreme eastern and western points of the British Islands.

In addition to these reasons for selecting the arc from Valentia to Harwich in preference to any other, there exists a special reason for adopting Valentia as the extreme western station in preference to any point on the Dingle peninsula or farther north. From the astronomical advantages of referring all longitudes to Greenwich, and from the practical convenience of carrying chronometers through London, it is almost absolutely necessary to make Greenwich an intermediate point in any determination of differences of longitude: and, therefore, although it is intended that the arc shall ultimately be extended to the eastern coast, Greenwich may be for some time its real eastern termination. It is therefore desirable to choose for the western extremity a point whose latitude is not very different from that of Greenwich: and Valentia, being somewhat north of Greenwich, is therefore more favourably situated than any other place which is still farther north.

For these reasons I had, as long ago as the year 1836, proposed to myself the accurate determination of the longitude of Valentia as an object to be followed up at the first favourable opportunity. Accidental circumstances compelled me to defer it for a time; but I frequently discussed with Mr. Sheepshanks the plan of proceeding most proper for such a determination.

Two advantageous circumstances resulted from this delay. First, that the Ordnance Survey of Ireland, which before had reached only to the higher mountains of Kerry, was carried to the island of Valentia. Secondly, that the formation of the English railways had greatly facilitated the conveyance of chronometers.

In the summer of 1843 I went to Valentia to examine the localities and to select a station. And here I found reasons, of which I was not aware before, for preferring Valentia as a western extremity to the Dingle peninsula or any other part of the coast. The country is for the most part extremely mountainous, even to the edge of the sea. The Dingle peninsula consists of a cluster of mountains about 3000 feet high, the highest of which, Brandon Hill, breaks down very steeply to the sea. The western extremity itself consists of a hill, Mount Eagle, whose height is about 1500 feet. In the valleys among

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these mountains, or at their bases, there would be obvious danger of great local disturbance: the only situation which would seem to be reasonably secure is the summit of Mount Eagle, whose elevation, in the humid atmosphere of the west of Ireland, renders it a very unfit place for astronomical observations. The island of Valentia, on the contrary, is at its highest point less than 900 feet high; it is completely separated from the mainland mountains by the sea-channel and the low land about Cahirsaveen; and these mountains are much inferior to those on the Dingle peninsula.

The points of Valentia most accurately determined by the Ordnance Survey are Bry Head (the western extremity of the island) and Feagh Main (the highest point of the island). Of these I selected for the western extremity of the arc of meridian the station of Feagh Main. The grounds of selection were these. First, that the station is nearly in the center of the island as regards the masses east and west of it: those to the west having a slight preponderance. Secondly, that the station commands land in the direction of the meridian, so that a south mark can be fixed at the distance of about two miles within the island, or at a greater distance on the mainland: a power of securing instrumental reference which is sometimes important when a portable transit instrument is placed on a temporary mounting, in a climate so uncertain as that of the west of Ireland.

Colonel Colby, on being made acquainted with my selection of Feagh Main, immediately took measures for determining accurately its latitude. Under his instructions Lieutenant Hornby proceeded with the Ordnance Zenith Sector to that station in the month of August, 1843, and made a number of observations sufficiently great to leave no probable error of perceptible amount.

In the autumn of 1843 I submitted to the Lords Commissioners of the Admiralty a proposal for the determination of the longitude of Feagh Main, by the transmission of chronometers; and immediately received from their Lordships full authority for proceeding with this enterprise. Their Lordships, also, on my representation, requested the Master-General and Board of Ordnance to despatch an officer of the corps of Royal Engineers, with a party of Royal Sappers and Miners, to make the transit observations and transact the general operations at the station of Feagh Main. The Master-General and Board of Ordnance immediately complied with this request; and, the selection of an officer being referred to Colonel Colby, Lieutenant Gosset, a most able and zealous officer, was appointed to this duty. This gentleman, at the first interval of his military

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employments, stationed himself at Greenwich for the purpose of making himself acquainted with the routine of operations in circumstances similar to those of his future post, and at a subsequent time acquired additional familiarity with them by observing with Mr. Sheepshanks at Kingstown. The result will show how fortunate for the satisfactory termination of the work was the choice of the Valentia observer.

II.—*Description of the Route selected for the Chronometers, of the Subdivisions of the Arc, of the Method of Conveying the Chronometers, and of the Transit-Stations.*

The Lords of the Admiralty had intimated to me their willingness to employ on this expedition a Government steamer, for the purpose of conveying the chronometers to Valentia from Bristol or any other port which might seem well adapted to this purpose. But upon my representation of the reduction of expense, as well as the more perfect command of time, which might be obtained by using other methods of conveyance, their Lordships were pleased to sanction my proposal for carrying the chronometers across Ireland by land conveyance. It will shortly be seen that this arrangement was attended with the collateral advantages of determining the longitudes of two important ports.

The lines of route between which a selection was to be made were the following:—1. By Bristol to Cork, and thence to Killarney and Valentia. 2. By Pembroke to Waterford, and thence to Killarney and Valentia. 3. By Holyhead to Kingstown, and thence to Dublin, Limerick, Tralee, and Valentia. 4. By Liverpool to Kingstown, and thence (as in the 3rd) to Valentia. The preference would depend, in a great measure, upon the shortness of the land conveyance, and the extent to which it was effected by railway-carriage; but still more upon the frequency and regularity of the steam-boats. In regard to the former of these points only, the route by Bristol and Cork was best; but, in consideration of the latter in conjunction with the former, I determined on adopting the route by Liverpool and Kingstown.

I had proposed to carry the chronometers through the whole length of the line, from Greenwich to Valentia, without any other interruption than was necessary for winding up the chronometers and possibly for comparison with a clock at Kingstown; and this would have been done without any difficulty. But at the representation of Mr. Sheepshanks (to whom, as will be seen, this

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expedition is very much more indebted than to myself), it was decided to divide the arc into two parts, making the longitude of Kingstown from Greenwich and that of Valentia from Kingstown the subjects of two separate determinations; and even subdividing the arc from Greenwich to Kingstown by the station of Liverpool, if opportunity should present itself. The principal reason for thus dividing the long arc into shorter arcs was, that, if the chronometer-rates should be gradually changing, the aggregate of the effects of their errors on the small arcs would be less than the single effect on the large arc; there was also the general fear that, in so long a series of arrangements in which accurate attention to every one was necessary for the success of all, the omission of some very small point might for a time entirely interrupt the whole operation. On the other hand there was the danger, in making the different sections of the arc independent, that some constant error might creep in at their junction. To guard against this I made it a fundamental point that the same transit, in the same position, with the same meridian mark, and, if possible, with the same observer, should be employed through the whole series of observations at Kingstown. To remove all difficulties on the last-mentioned head, Mr. Sheepshanks undertook himself, regardless of the personal labour, the confinement, and the private expense thus incurred, to conduct the Kingstown observations as far as possible. Ill health compelled Mr. Sheepshanks at length to desist, but such measures were taken by him for comparison of his methods of observation with that of the person who took his place, that the continuity of the observations may be considered as having been as completely established as if Mr. Sheepshanks had taken every transit himself.

For comparison of the transit-clocks at the different stations thirty pocket-chronometers were used. They were placed in two large flat cases, each case carrying fifteen chronometers. Each chronometer occupied a separate cell, within which it rested upon a wooden support, cut to the form of the chronometer; the support was urged upwards by springs (as is usual in the boxes of pocket-chronometers), while the face of the chronometer was pressed downwards by the padded lid of the large flat case. This arrangement is unobjectionable if the springs are sufficiently strong; but, taking into account the possibility of the springs yielding too much or breaking, I think it might be preferable in general to support the chronometer upon a small padded cushion. The outsides of these flat cases—bottoms, sides, ends, and tops—were covered with a thick padding. This secured the chronometers perfectly from

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tremor transmitted through the flat cases; although they were still liable to the effects of internal tremor within their cells produced by very violent motion of their cases.

The general plan of conveyance of the chronometers was this. A great number of strong boxes were constructed, all exactly similar, and of such dimensions that the large flat cases could be thrust easily into any one of them (one flat case upon the other), and could there be held firmly by the pressure of the bottom, sides, and top of the strong box upon the padding of the flat cases. The strong boxes were all furnished with similar locks, which could all be opened by the same key. One of these strong boxes was attached by powerful screws to every one of the railway-carriages, steam-boats, and mail-coaches, which could by any possibility be used for the conveyance of the chronometers; one was wedged by straw-padding into the luggage-box of the Irish car used in one part of the journey; one was appropriated to each short line in which the chronometers were conveyed by carriages used for the occasion; and several were kept in store at the principal stations, ready to be fixed in case of the unexpected substitution of any new carriage or steam-boat in the place of those usually making the journey. At each of the stations where the course of any railway-carriage, steam-boat, mail-coach, or car, began or ended, an agent was stationed, who was furnished with a key which would open any of the locks. Thus the method of conveying the chronometers was as follows:—At the beginning of each section of the line an agent conveyed the flat cases to the carriage or steam-boat, placed them in the strong box, and locked it. The chronometers then travelled through the section, unattended by any guard (except in one part, which will be mentioned); and at the end of that section another agent unlocked the strong box and took the flat cases out of it. The general principle of these operations was suggested by Mr. Sheepshanks, and the details were arranged by me. In no instance did any of these arrangements fail.

The chronometers were conveyed between Greenwich and the Euston-Square Station of the London and Birmingham Railway in one of the large boxes, which was carried in an ordinary four-wheeled spring-carriage or fly, and was accompanied by an Assistant of the Royal Observatory: Mr. J. R. Hind in the first part of the operations, and Mr. E. Dunkin in the latter part.

For facilities in the railway conveyance I am indebted to the kindness of

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R. Creed, Esq., Secretary of the London and Birmingham Railway Company; of H. P. Bruyères, Esq., Superintendant of the Railway, and of Captain Huish, Secretary of the Grand Junction Railway. And I can truly say that by the promptitude with which these gentlemen acceded to my requests, and by the co-operation of all the railway officers which they enforced, the railway was made in all respects as available for my purpose as if it had been my own property. Carriages were selected, among the class of those carrying imperials on the roof, which traversed the whole line between London and Liverpool; and in each of these, in that division of the imperial in which it was least probable that parcels would be placed, one of my large boxes was screwed. The trains by which they were conveyed were the day trains, which corresponded most nearly with the night mail-steam-boats between Liverpool and Kingstown.

The conveyance of the chronometers between the railway station at Liverpool and the mail-steamer was managed by Mr. Hartnup, Director of the Liverpool Observatory. On my stating to Mr. Hartnup the nature of the assistance desired at Liverpool, he immediately undertook to be in attendance with one of my large boxes in an easy carriage at the arrival of each of the railway-trains or steam-boats bringing chronometers, and to transfer them carefully to the steam-boat or train which was to carry them on.

Between Liverpool and Kingstown the chronometers were conveyed by the Contract Mail Steam-boats. For the permission to fix my large boxes in these vessels, and to have access to them for depositing and withdrawing the chronometers, I applied to Captain Bevis, R.N., Superintendant (on the part of the Government) of the Liverpool Mail Steamers, and to Charles Williams, Esq., Managing Director of the City of Dublin Steam Company, by whom the steamers for this service are supplied. I am most grateful to these gentlemen for the facilities of every kind which were afforded me, and for the gratuitous and careful conveyance of the boxes in their crowded ships.

From Kingstown to the Mail-coach Office at Dublin the chronometer cases were conveyed (in a large box appropriated to this line) in one of the carriages of the Kingstown Railway, and in a car through the streets of Dublin. Mr. Hind always accompanied them in this part of their journey.

By the good offices of Lieutenant-Colonel Maberly, Secretary of the General Post-office, and of James Cumming, Esq., Inspector of Mail-coaches at Dublin, I was permitted to attach my boxes to the top of the Dublin and Limerick

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mail, and to that of the Limerick and Tralee mail. At Limerick, a private of the corps of Royal Sappers and Miners, who had been selected for this service by Colonel Colby, and on whose care I could rely most perfectly, transferred the cases between the box on the Limerick mail and that on the Tralee mail. It was deemed expedient that he should accompany it on the mail between Limerick and Tralee, as this mail carries a greater number of passengers, and has less room for luggage, and there was, therefore, greater fear of violence than when the chronometers travelled by the Limerick mail.

At Tralee another private of the same corps was in attendance, and by these two persons the chronometers were wound up. They had been most carefully instructed in the cautions necessary for winding up chronometers, and a room was specially engaged for this purpose; and I have no doubt that this service was most correctly performed. It was only in this section of the arc that it was necessary to wind up the chronometers upon their journey.

Arrangements had been made with Mr. Bianconi for the supply of a car with four relays of horses for the conveyance of the cases in a box, wedged firmly by straw mats in the car-box, between Tralee and the Cahirsaveen ferry. They were accompanied by the private soldier who was in attendance at the arrival of the Limerick mail-coach at Tralee.

As the arrival at and the departure from Cahirsaveen occurred in the night, it was necessary to make a special arrangement for a boat to cross the channel. On my application to Captain Hornby, R.N., Inspector of the Coast Guard, and Sir James Dombrain, Inspector of the Coast Guard for Ireland, instructions were given to Mr. Quadling, the officer in charge of the force on the Cahirsaveen and Valentia station, to place a boat and the necessary party of men at my command. This service was performed by Mr. Quadling with the utmost good will and the most perfect regularity. The cases were conveyed in one of the large boxes, which was carried unfixed in the boat.

Between the Valentia side of the ferry and the station of Feagh Main (a distance of three miles, with a rise of nearly 900 feet), the large box was carried by two men, by means of two poles fixed in staples, in the manner of a sedan-chair. For about three-fourths of the distance, in which about one-half of the ascent is surmounted, the road is very good; after this the ascent is rather steep, upon grass, with occasionally trifling projections of rock. Some pains, however, had been taken to smooth the path and to make it visible in the night, and the chronometers were carried perfectly well.

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In the enumeration of the arrangements for the different sections of the chronometer-route, the process of conveying the chronometers must at first appear very complicated. Yet, in fact, it was not so. Considerable care was necessary in the preliminary arrangements; but, when these had been effected, the whole operation went on in the most orderly and (apparently) in the most simple manner, and there was no failure of any kind in the whole.

I shall now advert to the transit-stations.

Of the Liverpool transit-station it will be sufficient to say that it was the Liverpool Observatory, near the Waterloo Dock.

For the selection of a transit-station at Kingstown, and for the preparation of the small observatory, the pier to support the transit-instrument, &c., I am indebted to the kindness of Captain Larcom, R.E., and Lieutenant Leach, R.E., acting under the instructions of Colonel Colby. The place chosen was behind the Harbour-master's house, upon some broken ground above a quarry, at a convenient distance from the Royal Hotel, at which the observers resided during the observations. This point will be preserved by the erection of a small pier, fixed in the place of the transit-pier by the care of Captain Larcom. To the courtesy of Captain Hutchinson, the Harbour-master, we are indebted for facilities of access to the observatory. The observatory itself was a building of wood, 10 feet square and 10 feet high to the ridge; its shutter-opening, 1 foot wide, ran along the ridge and down the ends of the building as far as was necessary (an arrangement which I have repeatedly found convenient). The transit-pier, which was founded on the rock, was built of brick and cement to the height of 20 inches above the floor, and a slab of Portland stone, 8 inches thick, was then laid upon it; to this height the dimensions of the pier were 4 feet in the east-and-west direction, and 2 feet in that north-and-south. Upon this slab were planted two uprights of Portland stone 3 feet high, the base of each being 14 by 16 inches, and the top of each 8 by 10 inches. These uprights carried the transit, an excellent instrument of 42 inches length, the property of Mr. Sheepshanks. From the description which I have given it will appear that the steadiness of the instrument, as dependent upon its mounting, might be considered equal to that in the best permanent observatories. The north meridian line passed nearly over the center of Kingstown Harbour, and the north meridian mark (a small circle of white marble in a black ground) was fixed in the edge of the northernmost part of the N.W. pier of the harbour.

The transit-station in Valentia was 153 feet 9 inches south of the survey-

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station, and about 4½ inches east of it. This station had been selected, and a pier of large slate stones had been built from the rock to the surface of the ground, by Lieutenant Hornby, at my request, in the summer of 1843. It was necessary to adopt a position somewhat south of the survey-station, in order to command the low ground of the island, on which it was proposed to plant the meridian mark. The observatory was a panelled hut covered with canvas, of the construction usually adopted by Colonel Colby for the operations of the Trigonometrical Survey. The transit-piers were formed of blocks of slate from the well-known Valentia quarries (which are not far below the station), but I am unable to state their dimensions. The transit-instrument was one of 30 inches length, the property of Mr. Sheepshanks. The meridian mark was a plate of metal, in which was made an aperture, through which the bright surface of the water of the Sound was seen by day and a lamp by night. It was fixed upon a large block of stone, which was placed on the sandy beach of the Sound (where it was guarded by a private of the corps of Royal Sappers and Miners). After this stone had been placed, some alarm was caused by the discovery that the sand was really based upon a peat-bog of unknown depth, which lies so far below the surface of the sand as only to be discovered by probing, and which apparently passes under the seawater of the Sound. But, after very careful examination of all the results of observation, it does not appear that there was the smallest motion of the meridian stone. In mounting the transit and erecting the observatory and neighbouring huts, in fixing the meridian mark, and, indeed, in every operation connected with the island of Valentia, the greatest assistance was given with the utmost kindness by the Knight of Kerry and by Bewicke Blackburn, Esq., the principal residents on the island.

The whole of the operations (including everything relating to the longitudes of Liverpool, Kingstown, and Valentia,) occupied nearly the whole time from the end of June to the end of September, 1844. The following were the courses of the chronometer-journeys :—

The chronometers left Greenwich the first time on the morning of June 27, and reached Kingstown the last time on the morning of July 27, having made nine journeys from Greenwich to Kingstown, and eight journeys from Kingstown to Greenwich.

They then left Kingstown for Liverpool on the evening of July 27, and were returned to Kingstown the last time on the morning of August 4, having made four journeys each way.

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They then left Kingstown for Valentia on the evening of August 5, and returned to Kingstown the last time on the morning of September 14, having made ten journeys each way.

After a short delay and transmission to Liverpool, the chronometers left Liverpool for Greenwich on the morning of September 21, and arrived finally in Greenwich on the evening of September 28, having made four journeys from Liverpool to Greenwich, and three from Greenwich to Liverpool.

III.—*Method of adopting Instrumental Errors of the Transit-instruments; Determination of Clock-errors; and Method of Using the Stationary Chronometers.*

The mere operation of observing transits must be so exactly similar in all cases that it would be useless to describe it in reference to these stations. I shall therefore confine my present remarks to those operations which are intermediate between the rough observations and the ultimate clock-error.

The methods of reduction of the observations made at Greenwich are fully explained in the printed Greenwich Obervations. Here I have only to remark that the error of collimation of the middle wire of the transit is determined by repeated reversions, and by observation, at each reversion, of a collimator mounted for the occasion; that from this, by the intervals of the wires ascertained from observations of Polaris, the error of collimation of the mean of the wires is found; that all imperfect transits are reduced by the same intervals to the mean of the wires; that a correction for the error of collimation is applied to every transit by means of a table of factors, of which the argument is the polar distance of the object observed; that the level is usually applied once each week, and, in the latter part of these observations, more frequently (each application consisting of twelve readings of the level in reversed positions), and that a correction for this error is applied to every transit by means of a table of factors, of which the argument is the polar distance of the object; that then, by a comparison of the corrected transits of any principal clock-star and a circumpolar star, or of the upper and lower transits of the same circumpolar star (Polaris and δ Ursæ Minoris being the only circumpolar stars employed), the error of azimuth is ascertained, and that corrections for this are applied to every transit by means of another table of factors. Some parts of these operations imply confidence in the extreme steadiness of the instrument as regards

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collimation and level error, of which I have no doubt; and I fully believe that the true clock-transits of the objects are obtained thus with all practicable accuracy. The clock-errors are found by comparing the transits thus obtained with the right ascensions of the principal stars of the Nautical Almanac list, using the mean places of the Greenwich Catalogue of 1439 Stars. The clock-error at any other time (as for the time of the comparison of chronometers) is found by simple interpolation between the means of the errors given by the nearest groups of clock-stars, or by applying the ascertained rate to the nearest group. No attempt is made to improve this determination, but absolute reliance is placed on the steadiness of the clock's rate.

Of the method of determining the clock-errors at Liverpool I cannot give a complete account. The following particulars, however, taken in combination with the well-known skill of the observer and the excellence of the transit-instrument, will be perfectly satisfactory.

The method of correcting or determining the error of collimation has not been explained to me; but on every evening (excepting only two) on which transits were observed for the clock-errors entering into these operations, part were observed with the illuminated end East and part with the illuminated end West, and thus the effect of error of collimation was practically eliminated. Of the determination of level-errors, or errors of azimuth, I have no account.

The error of the transit-clock was found by comparing the observed transits with the places of the stars in the Nautical Almanac, 1844, corrected for the difference between the mean places in the Nautical Almanac of 1844 and that of 1845; or, in some instances, with the places of smaller stars determined by means of the Nautical Almanac stars. The error was then carried forward to the time of comparison of chronometers: first, by the rate of the transit-clock; secondly, by means of the mean-time-clock, which was compared with the transit-clock; thirdly, by means of three chronometers, which were compared with the transit-clock; and the mean result was adopted. The principle of this combination will be explained more fully in speaking of the reductions at Kingstown and Valentia.

The observations at Kingstown and at Valentia were planned by Mr. Sheepshanks; their arrangement was guided in some degree by the considerations that the instruments were not permanently mounted, that the telescopes were scarcely sufficient for observation of stars in the day time, and that the climate is uncertain. A catalogue of stars near the equator was selected, and another catalogue

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of stars near the pole (some of which would be observed above and some below the pole); and it was intended that the places of these stars should be determined by subsequent observations at Greenwich; and they were accordingly so determined. Observations of the transits of these stars were made as often as possible, the transit being reversed in the middle of almost every group of observations, and some of the circumpolar stars, as well as stars near the equator, being included in each group. The level was applied several times in each group. During the day (at Kingstown), and in the day and the night (at Valentia), the meridian mark was repeatedly observed in reversed positions of the transit, and a drawing of its appearance, as seen under the central wire, was usually made.

The reduction of these observations was effected under my direction, and, I believe, in the manner originally contemplated by Mr. Sheepshanks, except so far as regards the error of collimation.

The first step was to complete the imperfect transits. For the Kingstown transit-instrument, all the complete transits, from June 24 to August 20, 264 in number, were collected, and by means of these the equatoreal intervals of wires were found. With these intervals all the imperfect observations were reduced to the mean of the seven wires. For the Valentia transit-instrument, the complete transits were so few that I thought it best to use intervals previously determined by Mr. Sheepshanks, which appeared (so far as I could judge) to be sufficiently accurate. With these the transits were in all cases reduced to the middle wire.

Mr. Sheepshanks had proposed, in reference to the determination of error of collimation, first to apply to each transit the correction for the level-error (as given by a proper table of factors), and then to determine the error of collimation, either by those slowly-moving stars whose transits were observed partly in one position of the transit and partly in the reversed position, or by so adjusting the numerical values of the error of collimation and the azimuthal error, that the results of the two series of observations in reversed positions should harmonize. This method is, in my opinion, not proper for use when observations of a meridian mark can be obtained. It appears to me unsafe to use, for the determination of the relation between an optical axis and a mechanical axis, with which neither the diameters of pivots, nor the fundamental places of stars, nor the steadiness of clock-rates, have any connexion whatever, a method which is vitiated by errors in the diameters of the pivots, or in the

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fundamental places of the stars, or in the rate of the clock; and this when there does exist a method immediately and naturally related to the object sought, and totally free from the effects of all those errors. As long ago as 1828 (as is recorded in the first volume of the Cambridge Observations) I had endeavoured to obtain instrumental errors by observations of well-known stars with the firmly-mounted transit-instrument of the Cambridge Observatory, and I gave up the method in disgust. At Kingstown and Valentia, where there were numerous and excellent observations of a meridian mark, I thought it imprudent to attempt to use that method, except for those observations of slowly-moving stars, partly in one position of the transit and partly in the reversed position, which presented results almost at sight. The method employed, therefore, was this. From linear measure and distance of the meridian mark its angular breadth was computed. With this, and with the drawings of the appearance of the mark under the wire, a numerical value was assigned to the error of collimation of the middle wire. (I may remark that this value was always consistent; whereas those given by stars, as is above mentioned, were not consistent.) For the Kingstown transit-instrument this was corrected so as to apply to the mean of the seven wires. In both cases the effect of diurnal aberration was combined with the error of collimation. Corrections were applied to the transits, by the use of a proper table, for the determined errors of collimation. The difference of diameters of the pivots having been ascertained by frequent levellings, the proper alteration was applied to the results of each levelling during a group of observations, and the level-error so altered was used for the second correction of the transits. Then by comparing the clock-errors given by circumpolar stars above and below the pole, or by comparing those given by circumpolar stars and by equatoreal stars, an azimuthal error was obtained for each group. But this azimuthal error was not immediately applied to the transits. In combination with the error of collimation, and with the recorded appearance of the meridian mark, it gave an azimuth of the meridian mark: the mean of all the separate results of this kind through the whole series of observations gave a very accurate azimuth of the meridian mark; and then this azimuth, with the error of collimation at any time, and the recorded appearance of the meridian mark, gave an azimuthal error of the transit-instrument for that time. Corrections found from this error by a proper table of factors were applied to all the transits.

The clock-error was found by comparing the transit thus corrected with

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the star's apparent right ascension (formed by applying the ordinary star-corrections to the mean places determined by subsequent Greenwich observations), and the mean of all for each group was adopted for the mean time of that group; and no alteration was made in this adopted error.

A clock-error was thus obtained, at certain hours of the night, when the sky was clear, to which no objection could be made, and which, at any rate, was the only foundation for any clock-errors that were to be used in the comparison of the transit-clock with the travelling chronometers. But these travelling chronometers, under the most favourable circumstances, would be compared with the transit-clock at an interval of some hours from the transits, and when the sky was clouded there might be an interval of some days. It was doubtful whether absolute reliance could be placed on the steadiness of rate of the transit-clock during such an interval. This consideration induced Mr. Sheepshanks to adopt a method of preserving a good indication of time, which, so far as I know, is novel, and which is admirably adapted to these and similar circumstances. Several box-chronometers and one clock (in addition to the transit-clock) were carried to the stations. Some of these box-chronometers went solar time nearly, and some went sidereal time nearly. A solar chronometer admits of being compared with a sidereal transit-clock to an almost inconceivable accuracy by coincidence of beats. For, upon listening to the mingled beats of the clock and chronometer, the ear will soon be struck by a recurrence of double beats at which the sidereal clock follows the solar chronometer by a small fraction of a second; by the successive gains of the sidereal clock upon the solar chronometer their beats will at length coincide; and a good ear, with a little practice, can certainly fix on the time when the beats coincide within less than the hundredth part of a second. In like manner the sidereal chronometers can be compared with the solar chronometer, &c., and thus a complete intercomparison of the whole system of clocks and chronometers may be obtained. This intercomparison was most scrupulously made at the time of every group of transit-observations (giving clock-error), and at the time of every comparison with travelling chronometers (when application of clock-error was required). It is evident that it gave the means, under proper treatment, of correcting the unsteadiness of the transit-clock if the chronometers were perfectly steady, or of combining their presumed partial steadiness with that of the transit-clock, so as to diminish the probable effects of the unsteadiness of the latter. The

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method by which they were treated for this purpose, as arranged by me, was as follows. By means of the transit-clock-error on sidereal time, as found from groups of transits, and assuming the uniformity of transit-clock-rate between one group and another, a transit-clock-error was interpolated for every comparison with a solar chronometer; and applying this to the transit-clock-time at comparison, the sidereal time was found. This sidereal time was converted into solar time, just as if it had been Greenwich sidereal time, by means of the Mean Solar Time of Transit of the first point of Aries in the Nautical Almanac, and the tables given in the Appendix to the Greenwich Observations, 1837. This solar time differs from the solar time at the place by $\frac{1}{366 \cdot 25}$ of its longitude; but as this correction is constant its effects may be everywhere neglected. The solar time thus found is compared with the time indicated by the solar chronometer, and thus the error of the latter on solar time (subject to the correction just mentioned) is found, and its rate is found. For the comparison of the next sidereal clock or chronometer with this solar chronometer, the error of the solar chronometer (subject to the correction) is interpolated and applied to the solar-chronometer-time at comparison, and thus the true solar time at comparison (subject to the correction) is found. This is converted into sidereal time, by the Sidereal Time at Mean Noon, and the equivalents for mean solar hours, minutes, and seconds in the Nautical Almanac, just as if it was Greenwich solar time: and thus the true sidereal time at the place (free from the correction) is found. Comparing this with the time indicated by the sidereal clock or chronometer, its error on sidereal time is found. This process was continued through all the stationary clocks and chronometers, and thus their errors on their respective kinds of time were found, at the time of every group of transit-observations, and at the time of every comparison with the travelling chronometers: the former as certain as transits could give them, the latter relying entirely on the steadiness of the transit-clock, and (sensibly) on nothing else. Now, for each clock or chronometer, assuming its error at the time of groups of transits to be certain, and its rate from group to group to be uniform, its error was computed for the time of comparison of travelling chronometers, and this error was compared with the error as above found on the supposition that the transit-clock's rate from group to group was uniform. If the former was greater (the error being always estimated positive when the clock was slow) it indicated that, as far as reliance could be placed on this

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clock or chronometer, the transit-clock-error for the time of comparison with travelling chronometers required increase. Using all in this manner, and using the transit-clock among them as indicating a correction 0, and giving such weights as the general steadiness of rate seemed to justify, a correction to the transit-clock-error at times of comparison with travelling chronometers was found.

In some instances the rate of the chronometer, &c., evidently underwent a gradual and regular change; and in the instance of the second clock at Kingstown (which, abstracting from this circumstance, appeared to go remarkably well,) the change of rate was very considerable. In these cases it was necessary to introduce second differences into the interpolation of the errors. This was effected by the following formula. The rate between two transit-groups being supposed to be the true rate at the time midway between these groups, the comparison of successive rates gave at once the daily increase of rate. Call this i. And let T be the whole interval between one transit-group and the next, and t the interval between the first transit-group and the travelling-chronometer-comparison under consideration. Then, the clock-error at the travelling-chronometer-comparison having been interpolated on the supposition of uniform rate between the transit groups, it requires the further correction

$$-\frac{t.\overline{T-t}}{2}.i.$$

The evaluation of the probable error of the transit-clock as adopted, after correction by means of the other chronometers, would be a matter of some difficulty. I shall only express my belief that it scarcely exceeds the probable error as obtained directly from the transits; and that the latter is very small.

IV.—*Transits at Greenwich, Personal Equations, Instrumental Errors, Places of Stars, and Results for Clock Error at the Time of Comparison with the Travelling Chronometers.*

In this Memoir it is not possible to give every step of the multitudinous calculations leading to the ultimate result. For some I shall refer to the printed Greenwich Observations, and others I shall totally omit.

The transits over individual wires, and the corrections for imperfect transits, will be found in the Greenwich Observations.

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Although the greater number of the transits at Greenwich were taken by Mr. Henry (H.) and Mr. Ellis (E.), a few were also taken by Mr. Main (M.), Mr. Rogerson (R.), and Mr. Hind (J. H.). The determination of their personal equations will be found in the Introductions to the Greenwich Observations; the result is that to reduce the values of "Clock Slow," given by their observations, to those which would have been given by Mr. Henry's observations, the following corrections must be applied: M. $-0^s{\cdot}05$; E. $-0^s{\cdot}30$; R. $-0^s{\cdot}14$; J. H. $0^s{\cdot}00$.* These are applied in the tabular statement which follows; and thus all the clock-errors are reduced to Mr. Henry's method of observing.

The determinations of instrumental error will be found in the Greenwich Observations.

During the whole of these observations the illuminated end of the Transit was East.

The following are the mean places for Jan. 1, 1844, of the stars observed:—

	h	m	s		h	m	s
α Andromedæ ..	0	0	19·97	α Serpentis	15	36	35·14
γ Pegasi	0	5	12·43	β^1 Scorpii.....	15	56	22·52
β Ceti	0	35	45·25	δ Ophiuchi	16	6	10·45
Polaris.....	1	3	17·60	Antares	16	19	51·07
α Arietis	1	58	23·47	α Herculis.....	17	7	32·05
γ Ceti	2	35	13·33	α Ophiuchi.....	17	27	41·60
α Ceti	2	54	7·84	μ Sagittarii	18	4	26·03
α Persei.....	3	13	12·89	δ Ursæ Minoris.	18	22	39·75
Rigel.....	5	7	2·49	α Lyræ	18	31	39·32
β Tauri	5	16	26·05	β Lyræ	18	44	19·16
δ Orionis.....	5	24	2·30	ζ Aquilæ	18	58	14·31
α Orionis.....	5	46	43·57	δ Aquilæ	19	17	37·84
Sirius	6	38	16·58	γ Aquilæ	19	38	50·53
Procyon.....	7	31	7·91	α Aquilæ	19	43	10·15
Pollux	7	35	45·63	β Aquilæ	19	47	38·89
Regulus.....	10	0	3·49	α^2 Capricorni..	20	9	23·61
Spica.....	13	16	58·84	ζ Cygni	21	6	17·90
Arcturus	14	8	32·78	ϵ Pegasi.....	21	36	31·35
ϵ Bootis.....	14	38	10·37	ζ Pegasi	22	33	40·94
α Libræ.....	14	42	15·44	α Pegasi	22	56	59·52
β Libræ.....	15	8	37·19	ι Piscium	23	31	55·61
α Coronæ.....	15	28	4·95				

* This is sufficiently accurate for the few instances in which Mr. Hind observed transits at Greenwich. For the more important application to the longitude of Kingstown as depending on Mr. Hind's observations, a different value is subsequently adopted.

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TRANSITS OBSERVED AT GREENWICH.

Month and Day, 1844.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation Found. (Mean of Wires *West*)	Error of Collimation Used. (Mean of Wires *West*)	Error of Level Found. (West Pivot *High*.)	Error of Level Used. (West Pivot *High*)
			h m s	"	"	"	"
June 7				+0·67			
June 21						+3·21	
June 24	Polaris S.P...	3	13 3 17·23		+0·67		+3·21
	Spica	7	13 16 52·75				
	β Libræ	7	15 8 31·67				
	α Coronæ ...	7	15 27 59·16				
	α Serpentis ..	7	15 36 29·62				
June 26							
June 27	Arcturus	7	14 8 23·99			+2·70	+2·70
	ε Bootis	7	14 38 1·71				
	β Libræ	4	15 8 29·04				
	α Coronæ ...	7	15 27 56·22				
	α Serpentis ..	7	15 36 26·95				
June 28	α Herculis ...	7	17 7 23·21				+1·67
	Polaris	5	1 3 22·27			+1·67	
June 29	α Coronæ ...	7	15 27 54·18				
	α Serpentis...	7	15 36 24·80				
June 30	δ Aquilæ.....	7	19 17 26·94			+2·12	+2·12
July 3	Antares	7	16 19 37·63			+1·20	+1·31
	α Herculis ...	7	17 7 17·76			+1·43	
July 6						+0·68	
July 7							
July 8	Polaris S.P...	2	13 3 13·06			+0·82	+0·91
	Spica	2	13 16 38·09				
	α Coronæ ...	5	15 27 44·43				
	α Serpentis...	7	15 36 14·90				
July 9	α Ophiuchi...	7	17 27 20·94				
	μ Sagittarii ..	7	18 4 5·96				
	δ Ursæ Minoris	5	18 22 21·71				
	α Lyræ	7	18 31 18·36				
	Polaris	2	1 3 18·70				
	α Persei	7	3 12 50·25				
July 10							
July 11	Procyon	7	7 30 42·91			+1·00	
	Polaris S.P...	2	13 3 13·95				

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TRANSITS OBSERVED AT GREENWICH.

Error of Azimuth Found. (West Pivot *South.*)	Error of Azimuth Used. (West Pivot *South.*)	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Travelling Chronometers.	Clock Slow used for Comparison with Trav. Chron.
″	″	s	s	s		s	h m	s
} +5·85	+5·85	18·83	27·40	8·57	H			
		53·25	1·83	8·58	H			
		32·16	40·78	8·62	H			
		59·61	8·08	8·47	H			
		30·09	38·58	8·49	H			
							1 20	10·48
	+5·73	24·41	35·63	11·22	E	−0·30		
		2·12	13·30	11·18	E	−0·30		
		29·50	40·77	11·27	E	−0·30		
		56·64	8·06	11·42	E	−0·30		
		27·39	38·57	11·18	E	−0·30		
		23·65	35·61	11·96	H			
} +5·73		18·65	31·57	12·92	E	−0·30		
		54·53	8·05	13·52	E	−0·30		
		25·20	38·56	13·36	E	−0·30	17 30	13·23
		27·36	41·68	14·32	H			
							1 50	14·61
		38·11	55·42	17·31	M	−0·05		
		18·11	35·62	17·51	M	−0·05	17 30	17·40
							2 25	17·82
							17 40	20·85
							2 50	22·44
} +3·90	+3·90	15·93	39·20	23·27	E	−0·30		
		38·40	1·68	23·28	E	−0·30		
		44·66	7·96	23·30	E	−0·30		
		15·16	38·51	23·35	E	−0·30		
	+2·83	21·16	45·25	24·09	H			
} +2·83		6·22	30·53	24·31	H			
		21·47	45·79	24·32	H			
		18·55	42·79	24·24	H			
} +4·47	+4·47	15·45	40·58	25·13	J H			
		50·43	15·64	25·21	E	−0·30		
							17 50	25·50
							3 0	25·99
	+3·06	43·14	9·31	26·17	H			
} +3·06		15·46	41·96	26·50	H			

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TRANSITS OBSERVED AT GREENWICH.

Month and Day, 1844.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation Found. (Mean of Wires *West*)	Error of Collimation Used. (Mean of Wires *West*)	Error of Level Found. (West Pivot *High.*)	Error of Level Used. (West Pivot *High*)
			h m s	s	s	s	s
July 11	α Coronæ ...	7	15 27 41·10		+0·67		+0·91
	α Serpentis...	7	15 36 11·65				
	β^1 Scorpii ...	7	15 55 59·52				
	δ Ophiuchi...	7	16 5 47·16				
	Antares	4	16 19 28·32				
July 13						+1·68	
July 14	Rigel	7	5 6 32·41				+1·45
	α Orionis	5	5 46 13·95				
	Sirius.....	4	6 37 46·08				
	Procyon	7	7 30 37·89			+1·21	
July 15	Polaris S.P...	3	13 3 12·08				
	δ Ursæ Minoris	4	18 22 13·58				
	β Lyræ.....	5	18 43 50·63				
	ζ Aquilæ.....	5	18 57 46·07				
	δ Aquilæ	7	19 17 9·85				
	γ Aquilæ	7	19 38 22·20				
	α Aquilæ	7	19 42 42·04				
	β Aquilæ	7	19 47 10·91				
July 16	α Herculis ...	7	17 7 2·71				+0·20
	α Ophiuchi...	7	17 27 12·30				
	δ Ursæ Minoris	4	18 22 14·99				
	α Lyræ.....	7	18 31 9·90				
	β Lyræ.....	5	18 43 49·77				
	α^2 Capricorni .	7	20 8 54·99				
	Polaris	5	1 3 12·28			+0·04	
July 17	β Tauri.....	7	5 15 53·43				
	α Orionis	7	5 46 10·52				
	Sirius.....	7	6 37 42·63				
	Procyon	4	7 30 34·55				
July 18	α Herculis ...	7	17 7 0·18				
	α Ophiuchi...	7	17 27 9·95			+0·35	
July 19	α Herculis ...	7	17 6 58·43				+0·32
	α Ophiuchi...	7	17 27 8·19				
	μ Sagittarii ..	7	18 3 53·45				
	δ Ursæ Minoris	3	18 22 6·94				
	α Lyræ	7	18 31 5·61				
	Polaris	5	1 3 13·18			+0·32	
July 20	Antares	7	16 19 17·26				
	α Herculis ...	7	17 6 57·56				
	α Ophiuchi...	7	17 27 7·26				
	μ Sagittarii ..	7	18 3 52·33				
	δ Ursæ Minoris	4	18 22 5·79				

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TRANSITS OBSERVED AT GREENWICH.

Error of Azimuth Found. (West Pivot *South.*)	Error of Azimuth Used. (West Pivot *South.*)	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Travelling Chronometers.	Clock Slow used for Comparison with Trav. Chron.
″	″	s	s	s			h m	s
	+3·06	41·30	7·92	26·62	H			
		11·87	38·48	26·61	H			
		59·79	26·52	26·73	H			
		47·40	14·12	26·72	H			
		28·60	55·40	26·80	H			
							18 0	29·24
							3 20	30·71
	+4·11	32·74	3·90	31·16	E	−0·30		
		14·25	45·21	30·96	E	−0·30		
		46·44	17·57	31·13	E	−0·30		
} +3·93		38·20	9·34	31·14	E	−0·30		
		14·25	45·38	31·13	E	−0·30		
} +4·29		13·00	44·68	31·68	E	−0·30		
		50·89	22·71	31·82	E	−0·30		
		46·37	18·13	31·76	E	−0·30		
		10·16	41·84	31·68	E	−0·30		
		22·50	54·42	31·92	E	−0·30		
		42·34	14·08	31·74	E	−0·30		
		11·22	42·84	31·62	E	−0·30		
	+6·42	3·03	35·58	32·55	H			
		12·64	45·23	32·59	H			
} +6·42		11·77	44·47	32·70	H			
		10·10	42·78	32·68	H			
		50·00	22·72	32·72	H			
	+0·60	55·09	27·90	32·81	H			
} +0·60		13·45	46·50	33·05	D			
	+1·76	53·54	28·20	34·66	H		18 10	33·98
		10·65	45·27	34·62	H			
		42·80	17·61	34·81	H			
		34·68	9·38	34·70	H			
		0·31	35·57	35·26	H			
		10·09	45·23	35·14	H			
							3 30	35·86
		58·57	35·57	37·00	E	−0·30		
		8·34	45·23	36·89	E	−0·30		
		53·63	30·56	36·93	E	−0·30		
} +0·70		6·19	43·91	37·72	E	−0·30		
		5·73	42·78	37·05	E	−0·30		
} +2·81		12·84	48·67	35·83	D			
	+1·44	17·42	55·34	37·92	H			
		57·69	35·56	37·87	H			
		7·39	45·22	37·83	H			
} +1·44		52·49	30·56	38·07	H			
		5·64	43·74	38·10	H			

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TRANSITS OBSERVED AT GREENWICH.

Month and Day, 1844.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation Found. (Mean of Wires *West*)	Error of Collimation Used. (Mean of Wires *West*)	Error of Level Found. (West Pivot *High*.)	Error of Level Used. (West Pivot *High*)
			h m s	″	″	″	″
July 20	α Lyræ.....	7	18 31 4·77		+0·67		+0·32
July 21	Spica	7	13 16 21·57				
	Polaris	2	1 3 10·34				
	Rigel	4	5 6 23·78				+1·27
	β Tauri.....	5	5 15 47·87				
	δ Orionis	7	5 23 23·54				
	α Orionis	7	5 46 4·86				
	δ Ursæ Min. S.P.	3	6 22 0·76				
	Sirius.....	7	6 37 37·13				
	Procyon	7	7 30 28·86				
	Pollux	4	7 35 6·82				
July 22	Regulus.....	5	9 59 24·51				
	Polaris S.P...	4	13 3 7·06				
	Spica	7	13 16 20·61				
	α Herculis ...	7	17 6 54·44				
	μ Sagittarii ..	4	18 3 49·33				
	δ Ursæ Minoris	5	18 22 2·92			+1·27	
July 23	Polaris S.P...	4	13 3 2·42				
	ε Bootis	7	14 37 30·37				
	α Libræ	7	14 41 36·03				
	β Libræ	5	15 7 57·80				
	α Coronæ....	7	15 27 25·17				
	α Serpentis ..	7	15 35 55·70				
	β^1 Scorpii....	7	15 55 43·49				
	δ Ophiuchi...	4	16 5 31·26				
	Antares	7	16 19 12·41				
	γ Aquilæ	7	19 38 11·81				
	α^2 Capricorni .	7	20 8 45·14				
	Sirius.....	7	6 37 34·50				+0·77
	Procyon	7	7 30 26·39				
	Pollux	5	7 35 4·27				
July 24	α Coronæ....	7	15 27 24·34				
	δ Ophiuchi...	7	16 5 30·47				
	Antares	7	16 19 11·58				
	α Herculis ...	7	17 6 52·08				
	δ Ursæ Minoris	4	18 21 59·56				
	α Andromedæ	4	23 59 39·51				
	γ Pegasi.....	7	0 4 31·68				
	Polaris	4	1 3 10·61				
	Sirius.....	7	6 37 33·17			+0·79	
July 25						+0·75	
July 26	α Ophiuchi...	7	17 26 59·49		+0·45		
	μ Sagittarii ..	7	18 3 44·67				

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TRANSITS OBSERVED AT GREENWICH.

Error of Azimuth Found. (West Pivot *South.*)	Error of Azimuth Used. (West Pivot *South.*)	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observers.	Correction for Personal Equation.	Clock Time of Comparison with Travelling Chronometers.	Clock Slow used for Comparison with Trav. Chron.
"	"	s	s	s			h m	s
	+1·44	4·89	42·77	37·88	H			
	+3·91	21·86	1·54	39·68	E	−0·30		
+3·01		6·76	50·28	43·52	P			
		24·09	4·06	39·97	H			
		48·13	28·31	40·18	H			
		23·83	4·00	40·17	H			
		5·14	45·36	40·22	H			
+4·81		1·91	43·49	41·58	H			
		37·46	17·68	40·22	H			
		29·15	9·43	40·28	H			
		7·08	47·42	40·34	H			
		24·80	5·21	40·41	H			
+3·01		9·25	50·72	41·47	H			
		20·93	1·53	40·60	H			
		54·72	35·55	40·83	H			
		49·68	30·55	40·87	H			
+4·81		2·31	43·38	41·07	H		18 40	40·86
							3 30	41·31
	+6·90	9·44	51·58	42·14	E	−0·30		
+6·90		30·72	12·95	42·23	E	−0·30		
		36·54	18·77	42·23	E	−0·30		
		58·28	40·56	42·28	E	−0·30		
		25·52	7·76	42·24	E	−0·30		
		56·12	38·37	42·25	E	−0·30		
		44·02	26·42	42·40	E	−0·30		
		31·72	14·02	42·30	E	−0·30		
		12·98	55·31	42·33	E	−0·30		
		12·22	54·48	42·26	E	−0·30		
		45·65	27·98	42·33	E	−0·30		
	+2·55	34·74	17·71	42·97	H			
		26·59	9·46	42·87	H			
		4·45	47·45	43·00	H			
		24·52	7·75	43·23	H			
		30·68	14·01	43·33	H			
		11·82	55·30	43·48	H			
+2·55		52·27	35·53	43·26	H			
		59·38	42·94	43·56	H			
	+3·29	39·71	23·63	43·92	E	−0·30		
		31·91	15·94	44·03	E	−0·30		
+3·29		8·86	52·94	44·08	E	−0·30		
		33·45	17·73	44·28	E	−0·30		
							3 30	44·91
		59·70	45·18	45·48	H			
		44·94	30·55	45·61	H			

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TRANSITS OBSERVED AT GREENWICH.

Month and Day. 1844.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation Found. (Mean of Wires *West*)	Error of Collimation Used. (Mean of Wires *West*)	Error of Level Found. (West Pivot *High*.)	Error of Level Used. (West Pivot *High*)
			h m s	"	"	"	"
August 9				+0·45		−0·29	
						−0·09	
						−0·43	
						−0·40	
Sept. 15 to 20						−0·04	
						−0·42	
						−0·20	
						−0·41	
						−0·06	
						+0·18	
						−0·19	
September 20	α^2 Capricorni .	7	20 8 35·64		+0·45		−0·21
	Polaris	4	1 3 38·11				
	Regulus	5	9 59 12·77				
September 21	β Aquilæ	7	19 46 49·05				
	ϵ Pegasi	7	21 35 42·00				
	γ Pegasi	7	0 4 23·24				
September 22						−0·22	
						−0·39	
September 23	Regulus	7	9 59 8·99		−0·91	−0·28	−0·19
September 24	Polaris S.P. . .	7	13 3 25·29				
	Arcturus.	4	14 7 37·57				
	γ Aquilæ	7	19 37 56·89				
	α Aquilæ	7	19 42 16·50				
	β Aquilæ	7	19 46 45·29				
	ζ Pegasi	7	22 32 47·86				
	α Pegasi	6	22 56 6·49				
	γ Pegasi	6	0 4 19·11				
	β Ceti.	4	0 34 52·22				
	Polaris	3	1 3 29·78				
	α Arietis	7	1 57 30·50			−0·21	
September 25	Polaris S.P. . .	4	13 3 26·24				
	Arcturus.	7	14 7 35·93			+0·02	
	δ Ursæ Minoris	4	18 21 24·94				
	β Lyræ.	4	18 43 22·90				
	δ Aquilæ.	4	19 16 42·62				
	α Aquilæ	7	19 42 14·80				
	β Aquilæ	7	19 46 43·60				
	α Andromedæ	7	23 59 25·60				
	γ Pegasi	7	0 4 17·93			+0·01	
	β Ceti.	7	0 34 50·45				
	Polaris	4	1 3 34·51			−0·16	
September 26	Polaris S.P. . .	3	13 3 24·96				
	Arcturus.	7	14 7 34·71				

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TRANSITS OBSERVED AT GREENWICH.

Error of Azimuth Found. (West Pivot *South.*)	Error of Azimuth Used. (West Pivot *South.*)	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Travelling Chronometers.	Clock Slow used for Comparison with Trav. Chron.
″	″	s	s	s		s	h m	s
	+2·70	35·83	27·79	51·96	E	−0·30		
+2·70		34·74	26·99	52·25	E	−0·30		
		12·91	5·70	52·79	R	−0·14		
		49·20	42·57	53·37	R	−0·14		
		42·14	35·48	53·34	R	−0·14	20 15	53·22
		23·37	16·97	53·60	R	−0·14		
							7 40	55·23
	−0·40	8·90	5·75	56·85	M	−0·05		
−0·40		27·29	27·71	60·42	M	−0·05		
		37·48	34·48	57·00	M	−0·05		
		56·80	54·02	57·22	M	−0·05		
		16·41	13·73	57·32	M	−0·05		
		45·20	42·52	57·32	M	−0·05		
		47·77	45·26	57·49	M	−0·05	20 5	57·28
		6·40	3·91	57·51	M	−0·05		
		19·02	16·99	57·97	J H			
		52·12	49·64	57·52	J H			
−0·40		27·72	27·80	60·08	J H			
		30·41	28·26	57·85	J H			
							7 55	58·17
−0·40		29·53	27·89	58·36	E	−0·30		
		35·87	34·47	58·60	E	−0·30		
	+0·92	23·16	20·69	57·53	E	−0·30		
		22·84	21·73	58·89	E	−0·30		
		42·60	41·36	58·76	E	−0·30		
		14·77	13·71	58·94	E	−0·30		
		43·57	42·50	58·93	E	−0·30		
		25·55	24·72	59·17	E	−0·30		
		17·90	17·00	59·10	E	−0·30		
		50·45	49·65	59·20	E	−0·30		
+0·92		30·46	28·00	57·54	E	−0·30		
+0·92		29·09	28·12	59·03	R	−0·14		
		34·67	34·46	59·79	R	−0·14		

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TRANSITS OBSERVED AT GREENWICH.

Month and Day. 1844.	Star's Name.	Number of Wires observed	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation Found. (Mean of Wires *West*)	Error of Collimation Used. (Mean of Wires *West*)	Error of Level Found. (West Pivot *High*.)	Error of Level Used. (West Pivot *High*)
			h m s	″	″	″	″
September 26	δ Ursæ Minoris	3	18 21 21·57		−0·91		−0·19
	β Lyræ.....	7	18 43 21·61				
	δ Aquilæ.....	7	19 16 41·04				
	α Aquilæ.....	7	19 42 13·48				
	β Aquilæ	7	19 46 42·30				
	ζ Cygni	7	21 5 21·24				
	γ Pegasi.....	4	0 4 16·54				
	Polaris.....	3	1 3 30·74				
September 27	Polaris S.P...	4	13 4 20·17				
	Arcturus	7	14 8 33·31				
	δ Ursæ Minoris	3	18 22 20·40				
	β Lyræ.....	7	18 44 20·04				
	δ Aquilæ.....	4	19 17 39·80				
	α Aquilæ	7	19 43 12·01				
	β Aquilæ	7	19 47 40·84				
	α^2 Capricorni.	7	20 9 26·04				
	α Andromedæ	7	0 0 22·84				
	γ Pegasi.....	7	0 5 15·19				
	β Ceti	7	0 35 47·80				
	Polaris.....	4	1 4 26·85				
	Regulus.....	6	10 0 3·83			−0·29	
September 28	Polaris S.P...	5	13 4 21·34				
	Arcturus	7	14 8 32·34				
	δ Ursæ Minoris	5	18 22 19·19				
	α Lyræ.....	7	18 31 39·29				
	β Lyræ.....	7	18 44 19·33				
	ζ Aquilæ.....	7	18 58 15·06				
	δ Aquilæ.....	7	19 17 38·88				
	γ Aquilæ.....	7	19 38 51·44				
	α Aquilæ.....	7	19 43 11·24				
	β Aquilæ.....	7	19 47 40·02				
	α^2 Capricorni.	7	20 9 25·19				
	ι Piscium	7	23 31 57·65				
	α Andromedæ	7	0 0 22·40				
	γ Pegasi.....	7	0 5 14·46				
	β Ceti.....	7	0 35 47·10				
	Polaris.....	4	1 4 28·40				
September 29	γ Ceti.....	7	2 35 13·70				
	α Ceti.....	7	2 54 8·32				
October 21				−0·91			

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TRANSITS OBSERVED AT GREENWICH.

Error of Azimuth Found. (West Pivot *South.*)	Error of Azimuth Used. (West Pivot *South.*)	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Travelling Chronometers.	Clock Slow used for Comparison with Trav. Chron.
″	″	s				s	h m	s
	+0·92	19·79	20·31	60·52	R	−0·14		
		21·55	21·70	60·15	R	−0·14		
		41·02	41·35	60·33	R	−0·14		
		13·45	13·70	60·25	R	−0·14		
		42·27	42·49	60·22	R	−0·14		
		21·19	21·62	60·43	R	−0·14	20 50	60·17
		16·51	17·00	60·49	R	−0·14		
+0·92		26·69	28·23	61·54	R	−0·14		
							7 40	60·72
+0·92		24·30	28·35	4·05	E	−0·30		
		33·27	34·45	1·18	E	−0·30		
		18·62	19·91	1·29	E	−0·30		
		19·98	21·68	1·70	E	−0·30		
		39·78	41·33	1·55	E	−0·30		
		11·98	13·68	1·70	E	−0·30		
		40·81	42·47	1·66	E	−0·30		
		26·03	27·69	1·66	E	−0·30		
		22·79	24·73	1·94	E	−0·30		
		15·16	17·01	1·85	E	−0·30		
		47·80	49·67	1·87	E	−0·30		
+0·92		22·80	28·48	5·68	E	−0·30		
	+0·69	3·79	5·82	2·03	M	−0·05		
+0·69		25·09	28·62	3·53	M	−0·05		
		32·30	34·44	2·14	M	−0·05		
		17·56	19·51	1·95	M	−0·05		
		39·20	41·52	2·32	M	−0·05		
		19·27	21·66	2·39	M	−0·05		
		15·02	17·42	2·40	M	−0·05		
		38·84	41·31	2·47	M	−0·05		
		51·40	53·95	2·55	M	−0·05		
		11·20	13·66	2·46	M	−0·05		
		39·98	42·45	2·47	M	−0·05		
		25·16	27·67	2·51	M	−0·05	20 30	2·45
		57·61	0·08	2·47	M	−0·05		
		22·34	24·73	2·39	M	−0·05		
		14·42	17·01	2·59	M	−0·05		
		47·08	49·67	2·59	M	−0·05		
		24·70	28·76	4·06	M	−0·05		
+0·69								
		13·66	17·69	4·03	E	−0·30		
		8·28	12·17	3·89	E	−0·30		

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V.—*Transits at Liverpool, and Results for the Error of the Transit-clock at Liverpool.*

The transit-observations, instrumental corrections, and comparisons of individual transits with tabular right ascensions, have not been transmitted to me. The results deduced from groups of transits were sent by Mr. Hartnup in the following form:—

ERRORS OF THE LIVERPOOL TRANSIT-CLOCK DERIVED IMMEDIATELY FROM GROUPS OF TRANSITS.

Day, 1844.		Sidereal Time.	Clock Error.	Number of Stars. (Illum. end West.)	Number of Stars. (Illum. end East.)	Daily Rate.
		h m	s			s
July	27	14 4	−48·55	0	5	
	29	13 52	−50·78	10	5	−1·12
August	2	11 37	−56·29	9	5	−1·41
	3	17 52	−58·10	7	4	−1·44
September	20	21 42	−59·48	13	7	
	21	22 44	−59·47	11	0	+0·01
	22	20 29	−59·58	10	9	−0·12
	24	22 36	−59·55	6	8	+0·03
	25	17 26	−59·71	10	8	−0·20
	26	16 17	−59·78	8	8	−0·07
	27	18 43	−59·88	11	4	−0·09
	27	10 2	−60·00	6	2	−0·16

From these the following errors are deduced for the time of comparison of the stationary chronometers:—

Day, 1844.		Sidereal Time.	Error, using Transit Clock's Rate.	Error, using Mean Time Clock's Rate.	Error, using Rate of Mean of Three Chronom.	Adopted Error.
		h m	s	s	s	s
July	27	6 15	−49·30	−49·27		−49·29
	29	5 21	−51·58	−51·59	−51·59	−51·59
August	1	11 57	−54·90	−54·70	−54·69	−54·76
	2	5 20	−57·36	−57·36	−57·40	−57·37
September	20	7 38	−59·48	−59·49		−59·49
	23	19 58	−59·56	−59·54		−59·55
	23	7 3	−59·56	−59·55		−59·56
	25	21 11	−59·72	−59·72		−59·72
	25	7 15	−59·76	−59·78		−59·77
	27	22 45	−59·90	−59·88		−59·89
	27	7 23	−59·98	−59·95		−59·97

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It appeared, upon examination of a resulting longitude, that these Errors are considered positive when the clock is fast, and that the Rates are considered positive when the clock is gaining. It was also noted by Mr. Hartnup, that the clock error had been ascertained by comparison of the observed transits with apparent places of stars derived from the mean places given in the Nautical Almanac, 1845. Now the places in the Nautical Almanac, 1845, are referred to the same assumed equinox as those in the Greenwich Observations of 1836, 1837, 1838, and 1839; and therefore (see the Introduction to the Greenwich Catalogue of 1439 Stars) their right ascensions ought to be increased by $-0^{s}\cdot09$, to make their assumed equinox the same as that of the Greenwich Catalogue of 1439 Stars, on which all other right ascensions in this Memoir are founded. Correcting for this we have the following results:—

	h	m		s		s
1844, July 27, at	6	15	sidereal, Clock Slow	+49·20,	Losing Rate	+1·12
29	5	21		+51·50		+1·41
Aug. 1	11	57		+54·67		+1·41
2	5	20		+57·28		+1·44
Sept. 20	7	38		+59·40		−0·01
23	19	58		+59·46		−0·03
23	7	3		+59·47		−0·03
25	21	11		+59·63		+0·07
25	7	15		+59·68		+0·07
27	22	45		+59·80		+0·16
27	7	23		+59·88		+0·16

VI.—*Transits at Kingstown, Personal Equations, Instrumental Errors, Catalogue of Clock Stars, First Results for Clock Error, and Results as amended by the Comparison of Stationary Chronometers.*

It has been stated that the transits at Kingstown were taken by Mr. Sheepshanks until ill health compelled him to desist. Mr. J. R. Hind (at that time one of the Assistants in the Magnetical and Meteorological Department of the Royal Observatory, Greenwich), in whose care and exactness, as I well knew, the most perfect reliance might be placed, was then sent to take the Kingstown transits. Mr. Sheepshanks, however, remained at Kingstown so long as to effect a satisfactory comparison of Mr. Hind's methods of observing with his

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own, for personal equation. Lieutenant Gosset passed through Kingstown about the same time, and his personal equation was ascertained as compared with Messrs. Sheepshanks and Hind. The observations upon which these depend will be found below among the transits; the results are as follows:—

$$\text{Clock Slow J.H.} - \text{Clock Slow S.} = -0^{s}\cdot 33$$
$$\text{Clock Slow J.H.} - \text{Clock Slow G.} = -0^{s}\cdot 04$$

As the greater number of transits at Kingstown were taken by Mr. Hind, it was thought expedient to reduce all the results to the values which they would have had if Mr. Hind had observed throughout.

Before entering upon the methods of determining the instrumental errors, I must remark that, the level scale was divided into parts corresponding to $15''$ of arc. From this circumstance, and from the general convenience of this quantity as a measure of the instrumental errors of transits, in the use of which the time is measured by seconds, this quantity was adopted throughout. It becomes desirable, therefore, to distinguish it by some name; and I propose in writing to call it a *fifteen''*, and to abbreviate it in the heading of the columns, &c., to f''.

The error of collimation was ascertained by noting the apparent position of the middle wire in reversed positions of the transit as seen upon the meridian mark, a circle 2 inches in diameter at the distance of $\frac{2}{3}$ of a mile, which therefore subtended an angle of $0^{f}\cdot 7$ nearly. On July 26 the error was sensibly corrected, but the instrument shortly afterwards received a slight blow. No other change was made in this adjustment. From careful examination of all the observations of the meridian mark, I infer that, Illuminated end East, the apparent error of collimation of the middle wire was—

$$\text{To the end of July } 25 = +\tfrac{1}{14}\text{ diameter of mark} = +0^{f}\cdot 03$$
$$\text{After 20 Ophiuchi, July } 26 = +\tfrac{1}{15}\text{ diameter of mark} = +0\cdot 06$$

But equatoreal stars come later on the mean of all the wires than on the middle wire (Ill. end East) by $0^{s}\cdot 01$ nearly. And the effect of diurnal aberration is $-0^{f}\cdot 01$ nearly. Thus we obtain—

Error of Collimation of the Mean of the Wires

$$\text{To the end of July } 25 \begin{cases} \text{Ill. end East} & +0^{f}\cdot 01 \\ \text{Ill. end West} & -0\cdot 03 \end{cases}$$

$$\text{After 20 Ophiuchi, July } 26 \begin{cases} \text{Ill. end East} & +0\cdot 04 \\ \text{Ill. end West} & -0\cdot 06 \end{cases}$$

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The level errors under the heading "Error of Level Found," is the result of sometimes two and sometimes four applications of the level; and the "Error of Level Used," is therefore sometimes the result of twenty applications. These applications were made frequently in different positions of the transit-telescope, as, elevated 45° to the N., 45° to the S., &c.; but after examination I could not discover any difference among these which would justify a separation of them into classes. The level was also frequently applied immediately before and after reversing the transit; but upon collecting all these instances, the result for correction applicable on account of inequality of pivots was only $0^{m}\cdot003$, which I have neglected. I have, therefore, in adopting the "Error of Level Used," combined the level observations taken before and after reversing. The adjusting screws affecting the axis-level were repeatedly altered; and one effect of this was, that the mean of all the level-errors is very nearly $=0$, so that the the mean result is independent of the accuracy of the scale divisions. I have no reason, however, to doubt their accuracy, as they had been carefully traced by Mr. Simms.

Before July 9, the azimuthal error was obtained only by the deductions from circumpolar stars. After that time, the mark and the stars were used in combination, in the manner already explained.

The places of the stars used for correcting the clock are all (with the exception of nine only) referred to the same equinox as the Greenwich Catalogue of 1439 Stars. Some places are taken from that Catalogue without alteration; some are combined with the results of later observations at the Royal Observatory; some are derived entirely from the later observations at the Royal Observatory; and, in a few instances, results have been used derived wholly or partially from Mr. Hartnup's observations at Liverpool. From the last mentioned right ascensions, $0^{s}\cdot09$ is always deducted, for the reason explained in Section V. The nine excepted stars are Capella, Cephei 51 (Hev.), η Ursæ Majoris, β Ursæ Minoris, ζ Ursæ Minoris, ϵ Ursæ Minoris, γ Draconis, λ Ursæ Minoris, and α Cygni; whose places were taken from the Nautical Almanac: nearly all had been corrected from late Greenwich Observations, but the constant $-0^{s}\cdot09$ was not applied: in the positions of these stars this omission is entirely unimportant.

The stars observed at Valentia were (as far as they went) the same as those observed at Kingstown, with very few additions. To avoid repetition the whole are included in the following catalogue.

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MEAN R.A. FOR 1844, JAN. 1, OF THE STARS OBSERVED AT KINGSTOWN AND VALENTIA.

Star's Name.	Mean R.A. 1844, Jan. 1.	Star's Name.	Mean R.A. 1844, Jan. 1.
	h m s		h m s
γ Pegasi	0 5 12·43	κ Ophiuchi	16 50 17·18
Polaris	1 3 17·60	30 Ophiuchi	16 52 50·12
Groombridge 642	3 16 8·13	ε Ursæ Minoris	17 2 9·06
Groombridge 746	3 44 15·78	α Herculis	17 7 32·05
Groombridge 779	4 0 12·65	A.S.C. 1998	17 18 21·36
Groombridge 856	4 31 25·12	A.S.C. 2004	17 20 52·23
Capella	5 5 10·51	λ Ophiuchi	17 23 32·11
Groombridge 944	5 12 36·82	α Ophiuchi	17 27 41·60
Groombridge 1004	5 43 6·06	ο Serpentis	17 32 38·94
α Orionis	5 46 43·57	β Ophiuchi	17 35 45·95
Cephei 51 (Hev.)	6 25 28·66	γ Ophiuchi	17 40 4·20
Piazzi VI. 292	6 57 52·74	ν Ophiuchi	17 50 26·22
Castor	7 24 38·21	γ Draconis	17 52 59·15
Procyon	7 31 7·91	70 Ophiuchi	17 57 34·21
Pollux	7 35 45·63	72 Ophiuchi	17 59 57·30
Groombridge 1359	7 38 43·95	δ Ursæ Minoris	18 22 39·75
Piazzi IX. 37	9 14 19·57	24 Ursæ Minoris	18 28 28·24
✱N.P.D. 11°. 47′	11 11 56·24	α Lyræ	18 31 39·32
9 Leonis	11 41 5·77	3 Aquilæ	18 35 1·47
9 Draconis	12 54 0·22	6 Aquilæ	18 38 53·74
Groombridge 1960	12 59 59·79	ε Lyræ	18 39 10·09
Spica	13 16 58·84	β Lyræ	18 44 19·16
η Ursæ Majoris	13 41 23·13	9 Aquilæ	18 48 42·41
η Bootis	13 47 15·32	ε Aquilæ	18 52 32·49
Arcturus	14 8 32·78	ζ Aquilæ	18 58 14·31
μ Virginis	14 34 50·61	19 Aquilæ	19 1 21·42
ε Bootis	14 38 10·37	21 Aquilæ	19 5 50·69
α Libræ	14 42 15·44	22 Aquilæ	19 8 47·72
β Ursæ Minoris	14 51 13·78	✱N.P.D. 6°. 19′	19 12 0·46
β Libræ	15 8 37·19	26 Aquilæ	19 12 13·04
5 Serpentis	15 11 21·16	δ Aquilæ	19 17 37·84
10 Serpentis	15 20 45·65	ν Aquilæ	19 18 32·28
37 Libræ	15 25 39·54	36 Aquilæ	19 22 30·17
α Coronæ	15 28 4·95	μ Aquilæ	19 26 28·01
α Serpentis	15 36 35·14	σ Aquilæ	19 31 29·52
λ Serpentis	15 38 52·53	χ Aquilæ	19 35 13·46
ζ Ursæ Minoris	15 49 45·92	γ Aquilæ	19 38 50·53
β^1 Scorpii	15 56 22·52	α Aquilæ	19 43 10·15
14 Scorpii	16 2 56·10	β Aquilæ	19 47 38·89
δ Ophiuchi	16 6 10·45	Aquilæ 204 (Bode)	19 51 18·09
ε Ophiuchi	16 10 4·21	Aquilæ 207 (Bode)	19 53 25·96
19 Ursæ Minoris	16 15 20·80	τ Aquilæ	19 56 31·02
υ Ophiuchi	16 18 22·28	θ Aquilæ	20 3 15·11
η Ursæ Minoris	16 22 7·89	α^1 Capricorni	20 8 59·69
λ Ophiuchi	16 23 2·94	α^2 Capricorni	20 9 23·61
ζ Ophiuchi	16 28 34·36	β Capricorni	20 12 14·34
20 Ophiuchi	16 41 12·55	λ Ursæ Minoris	20 18 15·00
ι Ophiuchi	16 46 37·69	ε Delphini	20 25 45·53

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Star's Name.	Mean R.A. 1844, Jan. 1.	Star's Name.	Mean R.A. 1844, Jan. 1.
	h m s		h m s
ζ Delphini	20 28 0·83	51 Aquarii	22 15 59·05
β Delphini	20 30 13·94	ζ Aquarii	22 20 47·62
α Delphini	20 32 23·47	η Aquarii	22 27 20·21
α Cygni	20 36 6·89	κ Aquarii	22 29 40·40
75 Draconis	20 37 45·44	*N.P.D. 2°. 42′	22 32 10·92
ε Aquarii	20 39 13·52	ζ Pegasi	22 33 40·94
μ Aquarii	20 44 14·01	3 Piscium	22 52 37·78
32 Vulpeculæ	20 47 54·67	α Pegasi	22 56 59·52
76 Draconis	20 53 30·56	Groombridge 4008	23 4 3·93
θ Capricorni	20 57 10·18	Groombridge 4009	23 4 16·98
ν Aquarii	21 1 5·34	γ Piscium	23 9 4·59
α Equulei	21 8 1·41	κ Piscium	23 18 56·06
β Aquarii	21 23 20·51	9 Piscium	23 19 15·18
γ Aquarii	22 13 35·69	ι Piscium	23 31 55·61

It appears only necessary to add, in explanation of the following transits, that, on July 13, the wind being so high as to make the clock nearly inaudible, the transits were observed with the Mean Solar Chronometer 2354. Three comparisons of the chronometer with the transit-clock were made, by coincidence of beats, one before, one during, and one after the transits; and between these the numbers by the transit-clock corresponding to those by the chronometer were interpolated.

The azimuth of the meridian mark, or x in the column of "Error of Azimuth Found from Observations of the Meridian Mark," was concluded, from the mean of all the comparisons of the Error of Azimuth Found from Stars with the Error of Azimuth Found from the Meridian Mark, to be $+0^{s}\cdot19$.

The transit-clock was an excellent clock with mercurial pendulum by Molyneux, the property of Mr. Sheepshanks.

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	f″	f″	f″	f″
June 27	E	Groomb. 779 S.P...	1	15 59 41·86		+0·01		+0·094
		ϑ Ophiuchi.....	6	16 5 55·27				
		ϵ Ophiuchi.....	4	16 9 49·06			+0·098	
		ζ Ophiuchi.....	1	16 28 19·24				
		Groomb. 856 S.P...	2	16 30 53·39				
		ι Ophiuchi.....	7	16 46 23·06				
		κ Ophiuchi.....	7	16 50 2·22				
		30 Ophiuchi	7	16 52 35·04				
	W	ϵ Ursæ Minoris	5	17 2 11·43		−0·03		
		α Herculis	3	17 7 17·11			+0·087	+0·062
		γ Pegasi	1	0 4 56·48			+0·107	
							+0·087	
		Polaris.....	4	1 4 38·28				
	E	Polaris.....	3	1 4 38·37		+0·01		
							+0·060	
							+0·083	
June 28	W	Procyon.....	6	7 30 49·58		−0·03		
		Pollux	5	7 35 28·58			+0·043	+0·140
		Polaris S.P.....	3	13 1 46·70			+0·083	
		Spica ,.....	7	13 16 41·09				
		Arcturus	7	14 8 16·03				
		μ Virginis	7	14 34 33·44				
		ϵ Bootis.....	6	14 37 54·12				
		α Libræ	2	14 41 57·87				
	E	β Ursæ Minoris....	6	14 51 3·44		+0·01		
		β Libræ.....	7	15 8 20·01				
		5 Serpentis.....	7	15 11 4·30				
		Groomb. 642 S.P...	1	15 15 17·60				
		10 Serpentis	7	15 20 28·79				
		37 Libræ	7	15 25 22·42				
		α Coronæ	7	15 27 48·84				
		α Serpentis	7	15 36 18·46				
		λ Serpentis.....	4	15 38 35·83				
		Groomb. 746 S.P...	3	15 43 45·15				
		ζ Ursæ Minoris	4	15 49 38·64				
		β Scorpii.....	7	15 56 5·23				
		ϑ Ophiuchi	7	16 5 53·63			+0·198	
		ϵ Ophiuchi.....	7	16 9 47·47				
June 30	W	Polaris S.P.....	4	13 3 4·13		−0·03	+0·225	+0·271
		Spica	7	13 16 40·15				
		η Ursæ Majoris	7	13 41 3·99				
		η Bootis.....	6	13 46 56·32				
		Arcturus	7	14 8 13·84				
		ϵ Bootis.....	7	14 37 51·64				
		α Libræ.....	3	14 41 57·10			+0·280	
	E	β Ursæ Minoris....	7	14 50 54·44		+0·01	+0·270	
		β Libræ.....	7	15 8 19·02				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	+4·17	+4·15	59·46	14·86	+15·40	S	−0·33		
	+4·17		58·82	14·16	+15·34				
			52·65	7·96	+15·31				
			23·07	38·30	+15·23				
	+4·16		11·75	26·95	+15·20				
	+4·16		26·01	41·28	+15·27				
			5·21	20·78	+15·57				
			38·59	53·97	+15·38				
	+4·12		56·84	12·76	+15·92				
	+4·12		19·86	35·61	+15·75			17 34	+15·16
	+3·93	+3·93	59·05	15·14	+16·09				
	+3·93		14·52	30·65	+16·13				
	+3·96		16·10	30·65	+14·55			3 46	+15·94
			52·50	9·21	+16·71				
			30·50	47·18	+16·68				
	+3·96		14·57	31·12	+16·55				
	+3·96		44·70	1·79	+17·09				
			18·44	35·62	+17·18				
			36·86	53·94	+17·08				
			56·16	13·29	+17·13				
			1·71	19·02	+17·31			14 47	+16·80
	+3·95		58·47	16·03	+17·56				
			23·63	40·77	+17·14				
			7·47	24·55	+17·08				
	+3·95		53·76	11·57	+17·81				
			31·96	49·07	+17·11				
			26·03	43·20	+17·17				
			50·92	8·06	+17·14				
			21·44	38·56	+17·12				
			38·78	55·95	+17·17				
	+3·85		1·34	18·28	+16·94				
	+3·85		31·17	48·59	+17·42				
			9·26	26·57	+17·31				
			57·03	14·16	+17·13				
			50·90	7·96	+17·06				
	+0·63	+0·71	13·71	32·87	+19·16				
	+0·63		40·89	1·77	+20·88				
			4·42	25·49	+21·07				
			56·95	18·09	+21·14				
			14·47	35·60	+21·13				
			52·23	13·27	+21·04				
			57·86	18·99	+21·13				
	+0·87		54·45	15·90	+21·45				
			19·80	40·76	+20·96				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
June 30	E	Groomb. 642 S.P...	1	15 15 45·30		+0·01		+0·271
		10 Serpentis	7	15 20 27·28				
		37 Libræ.....	7	15 25 21·26				
		α Coronæ.....	4	15 27 46·37				
		α Serpentis.....	7	15 36 16·73				
		λ Serpentis.....	7	15 38 34·04				
		Groomb. 746 S.P...	4	15 43 54·81				
		ζ Ursæ Minoris.....	2	15 49 27·30				
		β^1 Scorpii.....	6	15 56 4·64				
		Groomb. 779 S.P...	3	15 59 52·17				
		14 Scorpii	5	16 2 38·22				
		δ Ophiuchi.....	6	16 5 52·32				
		ε Ophiuchi	7	16 9 46·11			+0·310	
July 1		η Bootis.....	2	13 46 54·75			+0·257	+0·252
		Arcturus	7	14 8 12·09				
		Groomb. 779 S.P...	1	16 0 51·36				
		δ Ophiuchi.....	7	16 5 50·61				
		ε Ophiuchi	7	16 9 44·41				
		ε Ursæ Minoris.....	4	17 1 50·87			+0·248	
		Groomb. 944 S.P...	2	17 12 12·86			+0·187	+0·194
		Capella.....	7	5 4 47·64				
July 2	W	ε Ursæ Minoris.....	6	17 1 47·26		−0·03	+0·168	
		A. S. C. 1998	4	17 17 59·49			+0·182	
		A. S. C. 2004	7	17 20 30·14				
		h Ophiuchi.....	7	17 23 9·93				
		α Ophiuchi.....	7	17 27 19·31				
	E	β Ophiuchi	7	17 35 23·93		+0·01	+0·229	
		γ Ophiuchi	6	17 39 42·30				
		Groomb. 1004 S.P.	2	17 42 39·09				
		γ Draconis	7	17 53 36·64				
		δ Ursæ Minoris.....	5	18 22 21·69				
		Cephei 51 (Hev.) S.P.	4	18 24 57·93				
		ε Lyræ	7	18 38 47·95				
		β Lyræ	6	18 43 56·99				
July 4		ε Ursæ Minoris	4	17 1 44·37				+0·269
		Groomb. 944 S.P...	1	17 12 4·92				
		A. S. C. 1998	7	17 17 54·97				
		α Ophiuchi	3	17 27 14·87				
		Groomb. 1004 S.P.	1	17 42 32·41				
		γ Draconis	7	17 52 32·22				
		70 Ophiuchi	3	17 57 7·73			+0·289	
		δ Ursæ Minoris	4	18 22 20·87			+0·249	

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow Used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	+0·87	+0·71	48·94	12·18	+23·24	S	−0·33		
			28·01	49·07	+21·06				
			22·03	43·20	+21·17				
			47·00	8·05	+21·05				
			17·45	38·56	+21·11				
			34·75	55·93	+21·18				
	+0·78		56·69	18·52	+21·83				
	+0·78								
	+0·67		27·08	48·44	+21·36				
			5·46	26·57	+21·11				
	+0·67		54·07	15·19	+21·12				
			39·04	0·17	+21·13			16 12	+20·91
			53·08	14·15	+21·07				
			46·83	7·96	+21·08				
			55·40	18·08	+22·68				
			12·74	35·59	+22·85				
	+0·67		53·34	15·30	+21·96				
			51·36	14·15	+22·79				
			45·17	7·96	+22·79			17 23	+22·82
	+0·67		50·02	12·43	+22·41				
	+0·66								
	+0·66	+0·39	16·05	37·91	+21·86				
			47·99	12·50	+24·51			6 40	+24·04
			46·90	12·33	+25·43				
	+0·35		59·89	25·31	+25·42				
			30·54	56·07	+25·53				
			10·32	35·92	+25·60				
			19·69	45·24	+25·55				
			24·36	49·74	+25·38				
			42·73	8·04	+25·31				
	+0·35		40·71	5·54	+24·83				
	+0·42		36·99	2·42	+25·43				
	+0·42		20·99	46·51	+25·52				
			59·75	25·97	+26·22			18 47	+25·18
			48·30	13·54	+25·24				
			57·38	22·66	+25·28				
	+0·88	+0·84	43·17	12·14	+28·97				
	+0·76								
	+0·88		8·98	38·40	+29·42			17 33	+29 28
			55·84	25·31	+29·47				
			15·65	45·24	+29·59				
	+0·76		38·14	5·95	+27·81				
			32·71	2·41	+29·70				
			8·57	38·08	+29·51				
	+0·88		17·06	46·31	+29·25				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	f″	f″	f″	f″
July 4	E	Cephei 51 (Hev.) S.P.	2	18 24 49·54		+0·01		+0·269
	W	δ Ursæ Minoris	2	18 22 17·14		−0·03		
		Cephei 51 (Hev.) S.P.	4	18 24 53·36				
		ε Lyræ	2	18 38 43·22				
		β Lyræ	7	18 43 52·18				
		ζ Aquilæ.....	3	18 57 47·57				
July 5	E	β^1 Scorpii.....	7	15 55 54·56		+0·01		+0·236
		δ Ophiuchi.....	7	16 5 42·33				
		υ Ophiuchi.....	6	16 18 54·26				
		λ Ophiuchi.....	4	16 22 34·66				
		Groomb. 856 S.P...	5	16 30 55·95			+0·236	
July 6	W	ε Ursæ Minoris	7	17 1 39·03		−0·03		+0·172
		Groomb. 944 S.P...	5	17 12 4·81				
		A. S. C. 2004.....	4	17 20 22·03				
		η Ophiuchi.....	6	17 23 1·69				
		α Ophiuchi.....	7	17 27 11·07				
		β Ophiuchi.....	7	17 35 15·60				
		γ Ophiuchi.....	7	17 39 33·92				
		Groomb. 1004 S.P..	2	17 42 33·10				
		ν Ophiuchi.....	1	17 49 56·24				
		γ Draconis.....	3	17 52 27·94			+0·171	
		δ Ursæ Minoris	4	18 22 11·85				
		Cephei 51 (Hev.) S.P.	2	18 24 50·63				
	E	δ Ursæ Minoris	3	18 22 11·36		+0·01	+0·174	
		Cephei 51 (Hev.) S P.	3	18 24 50·90				
		β Lyræ.....	7	18 43 48·21				
		ζ Aquilæ	7	18 57 43·75				
July 9		β Leonis.....	7	11 40 27·37	0·00		+0·065	+0·101
		β Ursæ Minoris....	3	14 50 34·52			+0·127	
		β Libræ.....	5	15 7 59·61			+0·127	
		α Serpentis	2	15 35 57·72				
		β Ophiuchi	7	17 35 8·53				
		γ Ophiuchi.....	7	17 39 26·91				
		Groomb. 1004 S.P.	1	17 42 25·88				
		γ Draconis.....	5	17 52 21·20				
		70 Ophiuchi.....	7	17 56 56·92				
		72 Ophiuchi.....	7	17 59 19·76			+0·087	
July 10	W	β Ophiuchi.....	7	17 35 5·99		−0·03		+0·073
		Groomb. 1004 S.P..	2	17 42 24·20			+0·085	
							+0·075	
July 11		α Coronæ.....	2	15 27 21·62	+ 0·02		+0·060	+0·027
	E	δ Ursæ Minoris	2	18 21 58·50		+0·01		

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f"	*f"*	*f"*	s	s	s		s	h m	s
	+0·88	+0·84	56·12	26·27	+30·15	S	−0·33		
			12·66	46·31	+33·65				
			0·77	26·27	+25·50				
			43·78	13·55	+29·77				
			52·78	22·67	+29·89				
			48·30	18·05	+29·75				
		+0·34	54·99	26·55	+31·56			10 12	+30·62
	+0·34		42·76	14·14	+31·38				
			54·69	26·12	+31·43			16 16	+31·10
			35·09	6·42	+31·33				
	+0·34		56·39	27·82	+31·43				
	+0·27	+0·23	39·10	11·95	+32·85				
	+0·20								
	+0·27		5·44	38·74	+33·30				
			22·28	56·08	+33·80				
			1·95	35·93	+33·98				
			11·32	45·25	+33·93				
			15·85	49·76	+33·91				
			34·18	8·05	+33·87				
	+0·20		33·91	6·37	+32·46				
			56·50	30·36	+33·86				
			28·18	2·40	+34·22				
	+0·21		11·65	46·14	+34·49				
			51·53	26·52	+34·99				
			11·83	46·14	+34·31				
	+0·21		50·97	26·52	+35·55				
			48·50	22·68	+34·18			18 46	+33·72
			44·05	18·06	+34·01				
		+0·25	27·62	7·87	+40·25			9 31	+39·80
	+0·16		34·57	15·27	+40·70				
			59·90	40·70	+40·80				
x+0·06			57·98	38·50	+40·52				
			8·80	49·76	+40·96				
			27·17	8·06	+40·89				
	+0·16		27·17	7·06	+39·89			17 46	+40·63
			21·39	2·39	+41·00				
			57·19	38·09	+40·90				
			20·02	1·07	+41·05				
	−0·02	−0·02	5·99	49·76	+43·77				
	−0·02		23·51	7·30	+43·79			17 54	+43·40
		+0·16	21·70	7·92	+46·22				
	+0·08		57·57	45·46	+47·89			18 1	+46·19

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	s″	s″	s″	s″
July 11	E	Cephei 51 (Hev.) S.P.	1	18 24 39·66		+0·01		+0·027
	W	δ Ursæ Minoris	1	18 21 58·53		−0·03		
		α Lyræ.....	3	18 30 56·17			+0·017	
							+0·037	
July 12								
July 13		α Coronæ.....	5	15 27 15·82	0·00		+0·105	+0·075
		α Serpentis.....	5	15 35 46·42				
		ζ Ursæ Minoris	7	15 48 54·74				
		β^1 Scorpii.....	5	15 55 34·26				
		Groomb. 779 S.P...	1	15 59 24·79				
		δ Ophiuchi.....	7	16 5 21·90				
		ε Ophiuchi.....	6	16 9 15·76				
	E	α Ophiuchi.....	3	17 26 52·94		+0·01		
		β Ophiuchi.....	4	17 34 57·54				
		γ Ophiuchi	6	17 39 15·79				
		Groomb. 1004 S.P.	2	17 42 15·72				
		γ Draconis.....	2	17 52 9·14				
		70 Ophiuchi	2	17 56 45·87				
		72 Ophiuchi	6	17 59 8·74				
		δ Ursæ Minoris....	4	18 21 53·58			+0·100	
		Cephei 51 (Hev.) S.P.	2	18 24 32·34			+0·077	
	W	δ Ursæ Minoris.....	3	18 21 51·63		−0·03	+0·019	
		Cephei 51 (Hev.) S.P.	3	18 24 36·71				
		β Lyræ.....	2	18 43 30·46				
		ζ Aquilæ.....	5	18 57 25·75				
July 14	E	ζ Ursæ Minoris....	7	15 48 52·20		+0·01		+0·021
		β^1 Scorpii.....	4	15 55 31·99				
		Groomb. 779 S.P...	3	15 59 22·72				
		δ Ophiuchi.....	7	16 5 19·51				
		ε Ophiuchi.....	7	16 9 13·40				
	W	α Ophiuchi.....	7	17 26 50·35		−0·03		
		ο Serpentis.....	5	17 31 48·20				
		β Ophiuchi.....	7	17 34 55·00				
		γ Ophiuchi.....	7	17 39 13·35				
		Groomb. 1004 S.P.	2	17 42 15·35			+0·010	
		ν Ophiuchi.....	7	17 49 35·61				
		70 Ophiuchi.....	7	17 56 43·31				
		72 Ophiuchi.....	7	17 59 6·20				
		δ Ursæ Minoris....	2	18 21 47·58			+0·014	
							+0·025	
		Cephei 51 (Hev.) S.P.	1	18 24 33·70			+0·020	
							+0·037	
July 15	E	ζ Ursæ Minoris....	4	15 48 49·01		+0·01		+0·015
		β^1 Scorpii.....	3	15 55 29·13				

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Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
x−0·03	+0·08	+0·16	41·14	27·45	+46·31	S	−0·33		
x−0·03			56·93	45·46	+48·53				
			56·22	42·79	+46·57				
								9 28	+48·03
		+0·05	15·89	7·90	+52·01				
			46·48	38·50	+52·02				
	−0·04		54·83	47·33	+52·50				
	+0·07								
			34·30	26·50	+52·20				
	−0·04		24·88	16·81	+51·93				
			21·95	14·10	+52·15				
			15·81	7·90	+52·09			16 16	+51·72
			53·04	45·21	+52·17				
			57·64	49·76	+52·12				
			15·89	8·06	+52·17				
	+0·07		15·09	8·05	+52·96				
			9·28	2·35	+53·07				
			45·97	38·10	+52·13				
			8·84	1·08	+52·24				
	+0·13		54·35	45·09	+50·74				
			31·57	28·01	+56·44				
			51·73	45·09	+53·36				
	+0·13		36·77	28·01	+51·24				
			30·52	22·70	+52·18				
			25·81	18·11	+52·30				
	−0·08	−0·13	52·61	47·23	+54·62				
	−0·18								
			31·88	26·48	+54·60				
	−0·08		22·00	16·94	+54·94				
			19·42	14·10	+54·68				
			13·31	7·89	+54·58				
			50·25	45·21	+54·96			17 21	+54·52
			48·06	43·14	+55·08				
			54·88	49·76	+54·88				
			13·23	8·06	+54·83				
	−0·18		14·11	8·31	+54·20				
			35·47	30·38	+54·91				
			43·19	38·10	+54·91				
			6·10	1·08	+54·98				
	−0·14		48·58	44·88	+56·30				
	−0·14		32·26	28·30	+56·04				
	−0·17	0·00	49·13	47·14	+58·01				
			29·15	26·49	+57·34				

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Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
July 15	E	Groomb. 779 S.P...	3	15 59 20·26		+0·01	+0·031	+0·015
		δ Ophiuchi.....	7	16 5 16·77				
		ε Ophiuchi.....	7	16 9 10·53				
		19 Ursæ Minoris...	4	16 14 25·28				
		η Ursæ Minoris....	5	16 21 12·46				
		Groomb. 856 S.P...	7	16 30 31·55				
	W	ε Ursæ Minoris	4	17 1 14·01		−0·03	−0·001	
July 20								
July 21	E	ζ Ophiuchi.....	7	16 27 23·10		+0·01		+0·205
		Groomb. 856 S.P...	1	16 30 15·96				
		20 Ophiuchi	7	16 40 1·15				
		ι Ophiuchi.....	7	16 45 25·92			+0·203	
		κ Ophiuchi.....	7	16 49 5·29				
		30 Ophiuchi.....	7	16 51 38·58			+0·220	
		ε Ursæ Minoris	6	17 0 54·68				
		Groomb. 944 S.P...	3	17 11 29·04				
		α Ophiuchi	7	17 26 30·18				
		β Ophiuchi.....	7	17 34 34·64				
		γ Ophiuchi.....	7	17 38 53·04				
		ν Ophiuchi.....	7	17 49 15·43			+0·205	
		72 Ophiuchi.....	7	17 58 45·80			+0·200	
	W	δ Ursæ Minoris....	7	18 21 28·00		−0·03	+0·180	
		3 Aquilæ	5	18 33 50·70			+0·220	
		6 Aquilæ	7	18 37 42·90			+0·205	
		ε Aquilæ.....	7	18 51 21·42			+0·207	
		Piazzi VI. 292 S.P.	2	18 56 39·46				
		21 Aquilæ	7	19 4 39·66				
		22 Aquilæ	7	19 7 36·50				
		26 Aquilæ	7	19 11 2·07				
July 22		α Coronæ.....	7	15 27 50·34	+ 0·04		+0·217	+0·218
							−0·189	−0·196
		ζ Ursæ Minoris....	7	15 49 30·37			−0·167	
							−0·234	
July 23	E	Capella.....	5	5 4 50·50		+0·01	−0·282	−0·222
							−0·236	
July 24	W	η Ursæ Majoris....	6	13 41 1·92	+ 0·04	−0·03	−0·193	
							−0·177	
		Arcturus.....	5	14 8 11·95				
		ζ Ursæ Minoris....	2	15 49 23·13			+0·014	+0·025
		δ Ophiuchi.....	1	16 5 50·05				
		ε Ophiuchi.....	7	16 9 43·81				
		κ Ophiuchi.....	7	16 49 56·90				

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Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	−0·17	0·00	20·14	17·08	+56·94	S	−0·33		
			16·79	14·09	+57·30				
			10·55	7·89	+57·34				
	+0·07		25·38	22·59	+57·21				
	+0·07		12·56	9·77	+57·21				
	+0·07								
	+0·08		31·42	29·08	+57·66			16 45	+57·08
	+0·08		13·89	10·96	+57·07				
								16 47	+71·78
		+0·09	23·28	38·21	+74·93				
	+0·10		15·40	29·88	+74·48			12 55	+74·23
			1·33	16·46	+75·13				
			26·14	41·18	+75·04			16 38	+74·68
			5·51	20·71	+75·20				
			38·78	53·93	+75·15				
	+0·10								
	+0·05		55·77	10·21	+74·44				
	+0·05		27·82	41·77	+73·95				
			30·41	45·23	+74·82	J H	0·00		
			34·86	49·74	+74·88				
			53·25	8·05	+74·80				
			15·61	30·37	+74·76				
			46·02	1·07	+75·05	G	−0·04		
	+0·12		29·57	43·57	+74·00	J H	0·00		
			50·85	5·69	+74·84	G	−0·04		
			43·06	57·89	+74·83	J H	0·00		
			21·61	36·29	+74·68				
	+0·12		39·03	54·00	+74·97				
			39·83	54·73	+74·90				
			36·69	51·72	+75·03	G	−0·04		
			2·23	17·24	+75·01				
x−0·12									
x+0·04	+0·07	+0·07	50·56	7·77	+17·21	S	−0·33	15 1	+16·84
	+0·07		29·21	46·46	+17·25				
		+0·34	50·25	13·18	+22·93				
x−0·15									
x−0·10			1·55	24·90	+23·35			13 51	+23·20
			11·92	35·29	+23·37				
	+0·27		22·39	46·26	+23·87				
	+0·27		50·32	14·01	+23·69				
			44·08	7·81	+23·73				
			57·13	20·68	+23·55	J H	0·00		

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Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
July 24	W	30 Ophiuchi.....	3	16 52 30·30		−0·03		+0·025
		ϵ Ursæ Minoris....	7	17 1 49·15				
		α Ophiuchi.....	7	17 27 21·02				
		β Ophiuchi.....	6	17 35 25·77				
		γ Ophiuchi.....	6	17 39 44·12				
		ν Ophiuchi.....	3	17 50 7·02				
		70 Ophiuchi.....	7	17 57 14·21			+0·036	
		72 Ophiuchi	7	17 59 37·17			+0·025	
	E	δ Ursæ Minoris	7	18 22 19·15		+0·01	+0·023	
							+0·038	
		3 Aquilæ	7	18 34 41·27				
		6 Aquilæ	7	18 38 33·71				
		β Lyræ.....	6	18 43 58·51				
		9 Aquilæ	7	18 48 22·43				
		ϵ Aquilæ.....	7	18 52 12·15				
		Piazzi VI. 292 S.P.	3	18 57 30·47				
		ζ Aquilæ.....	7	18 57 54·07				
		21 Aquilæ	7	19 5 30·42				
		22 Aquilæ	4	19 8 27·42				
		26 Aquilæ	7	19 11 53·05				
		δ Aquilæ.....	7	19 17 17·53				
		36 Aquilæ	7	19 22 9·63				
		μ Aquilæ	7	19 26 7·39				
		σ Aquilæ	7	19 31 8·80				
		χ Aquilæ	7	19 34 52·82				
		γ Aquilæ	7	19 38 30·21				
		α Aquilæ	7	19 42 49·78				
		β Aquilæ	7	19 47 18·80				
		τ Aquilæ	3	19 56 10·75				
		θ Aquilæ.....	7	20 2 54·83			+0·014	
		α^1 Capricorni.....	2	20 8 40·67				
		α^2 Capricorni.....	7	20 9 3·55				
		β Capricorni.....	4	20 10 54·30				
		β Capricorni.....	3	20 10 54·33				
					+0·03			
July 26	W	ζ Ursæ Minoris	6	15 49 19·76	0·00	0·00	−0·066	−0·017
		β^1 Scorpii.....	7	15 55 59·04			−0·021	
		δ Ophiuchi.....	7	16 5 46·75				
		ϵ Ophiuchi.....	7	16 9 40·55				
		19 Ursæ Minoris...	3	16 14 55·71				
	E	η Ursæ Minoris	7	16 21 42·40		0·00		
		ζ Ophiuchi.....	7	16 28 10·87				
		Groomb. 856 S.P..	4	16 31 1·92				
		20 Ophiuchi.....	7	16 40 49·03				
		ι Ophiuchi.....	7	16 46 13·89		+0·04		
		κ Ophiuchi.....	6	16 49 53·24				
		30 Ophiuchi.....	7	16 52 26·60				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f''	*f''*	*f''*	s	s	s		s	h m	s
		+0·34	30·57	53·91	+23·34	J H	0·00		
	+0·80		47·86	9·80	+21·94				
	+0·80		21·24	45·19	+23·95	G	−0·04		
			26·02	49·73	+23·71				
			44·37	8·03	+23·66				
			7·31	30·37	+23·06				
			14·47	38·10	+23·63	J H	0·00		
			37·40	1·07	+23·67				
	+0·05		16·52	42·89	+26·37				
			41·59	5·70	+24·11				
			34·02	57·90	+23·88				
			58·69	22·70	+24·01				
			22·74	46·61	+23·87				
			12·40	36·30	+23·90				
	+0·05		32·11	54·29	+22·18				
			54·32	18·15	+23·83				
			30·71	54·74	+24·03				
			27·73	51·72	+23·99				
			53·36	17·25	+23·89				
			17·82	41·89	+24·07				
			9·93	34·34	+24·41	S	−0·33		
			7·67	32·00	+24·33				
			9·08	33·56	+24·48				
			53·08	17·40	+24·32				
			30·48	54·48	+24·00	G	−0·04		
			50·05	14·15	+24·10				
			19·08	42·90	+23·82				
			11·03	35·03	+24·00	J H	0·00		
			55·13	19·27	+24·14			20 0	+23·88
			41·01	4·07	+23·06				
			3·89	27·99	+24·10				
			54·65	18·76	+24·11	G	−0·04		
			54·68	18·76	+24·08	J H	0·00		
x+0·00									
x+0·00	+0·33		18·99	46·06	+27·07	S	−0·33		
			59·37	26·39	+27·02				
			47·02	13·99	+26·97				
			40·83	7·80	+26·97				
	+0·41		55·09	21·71	+26·62				
	+0·33		41·79	8·90	+27·11				
	+0·33		11·17	38·16	+26·99				
	+0·41								
	+0·33		3·53	30·61	+27·08				
			49·33	16·43	+27·10				
			14·15	41·15	+27·00				
			53·51	20·67	+27·16				
			26·92	53·90	+26·98				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s				
					f″	f″	f″	f″
July 26	E	ε Ursæ Minoris	4	17 1 44·81		+0·04		−0·017
		α Herculis	7	17 7 8·24				
		Groomb. 944 S.P...	3	17 12 13·32				
		α Ophiuchi.....	7	17 27 18·01			−0·175	
		ο Serpentis.....	7	17 32 16·05				
		β Ophiuchi.....	7	17 35 22·84				
		γ Ophiuchi.....	7	17 39 41·20				
		Groomb. 1004 S.P. .	1	17 42 41·88				
		ν Ophiuchi	7	17 50 3·55				
		70 Ophiuchi	4	17 57 11·10				
		72 Ophiuchi.....	7	17 59 34·00			−0·081	
	W	δ Ursæ Minoris.....	7	18 22 17·86		−0·06	−0·012	
		3 Aquilæ.....	7	18 34 38·52				
		6 Aquilæ	7	18 38 30·84				
		β Lyræ.....	7	18 43 55·51				
		9 Aquilæ	7	18 48 19·55				
		ε Aquilæ.....	7	18 52 9·19				
		Piazzi VI. 292 S.P.	4	18 57 26·72				
		ζ Aquilæ.....	7	18 57 51·22			+0·017	
		21 Aquilæ	7	19 5 27·17				
		22 Aquilæ	7	19 8 24·24				
		26 Aquilæ	2	19 11 49·81				
		δ Aquilæ.....	7	19 17 14·45				
		36 Aquilæ	7	19 22 6·78				
		μ Aquilæ.....	6	19 26 4·54				
		σ Aquilæ	7	19 31 6·07				
		χ Aquilæ	7	19 34 50·01				
		γ Aquilæ.....	7	19 38 27·01				
		α Aquilæ	7	19 42 46·66				
		β Aquilæ	7	19 47 15·38				
	E	Aquilæ 204 (Bode)	7	19 50 54·86		+0·04	−0·003	
		Aquilæ 207 (Bode)	6	19 53 2·47				
		τ Aquilæ.....	7	19 56 7·42				
		θ Aquilæ.....	6	20 2 51·74			+0·022	
		α^1 Capricorni	2	20 8 36·42			+0·028	
		α^2 Capricorni	7	20 9 0·22				
		β Capricorni.....	6	20 11 51·08				
		λ Ursæ Minoris	1	20 18 18·35			−0·035	
	W	λ Ursæ Minoris	1	20 18 25·42		−0·06		
July 27	E	70 Ophiuchi.....	7	17 57 9·55		+0·04		−0·079
		ζ Aquilæ.....	7	18 57 49·56			−0·051	
		19 Aquilæ.....	6	19 0 56·90				
		21 Aquilæ.....	7	19 5 26·20				
		22 Aquilæ.....	7	19 8 23·15				
		26 Aquilæ.....	7	19 11 48·58				
		δ Aquilæ.....	6	19 17 13·48				
		σ Aquilæ	5	19 31 4·92				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	+0·48	+0·34	43·77	9·52	+25·75	S	−0·33		
	+0·39								
			8·49	35·52	+27·03				
	+0·48		15·64	42·94	+27·30				
			18·27	45·18	+26·91				
			16·39	43·11	+26·72	J H	0·00		
			23·13	49·71	+26·58				
			41·49	8·02	+26·53				
	+0·39		45·27	11·84	+26·57				
			3·89	30·36	+26·47				
			11·40	38·10	+26·70				
			34·27	1·05	+26·78				
	+0·09		13·46	42·43	+28·97				
			38·75	5·70	+26·95				
			31·06	57·89	+26·83				
			55·56	22·69	+27·13				
			19·77	46·62	+26·85				
			9·34	36·29	+26·95				
	+0·09		29·15	54·49	+25·34				
			51·37	18·15	+26·78				
			27·37	54·75	+27·38	S	−0·33		
			24·45	51·73	+27·28				
			50·03	17·26	+27·23			19 10	+26·87
			14·64	41·90	+27·26				
			6·99	34·35	+27·36				
			4·72	32·02	+27·30				
			6·25	33·56	+27·31				
			50·17	17·40	+27·23				
			27·18	54·50	+27·32				
			46·83	14.16	+27·33				
			15·56	42·92	+27·36				
			55·20	22·43	+27·23				
			2·74	29·97	+27·23				
			7·70	35·05	+27·35				
			52·05	19·27	+27·22				
			36·77	4·08	+27·31				
	+0·32		0·57	28·00	+27·43				
			51·44	18·78	+27·34				
			9·80	38·90	+29·10				
	+0·32		11·89	38·90	+27·01				
								12 36	+28·04
		+0·16	9·66	38·08	+28·42	J H	0·00		
			49·65	18·15	+28·50				
			57·01	25·41	+28·40				
			26·31	54·75	+28·44				
			23·26	51·74	+28·48				
			48·72	17·26	+28·54	G	−0·04		
			13·59	41·89	+28·30	J H	0·00		
			5·03	33·57	+28·54	G	−0·04		

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
July 27	E	Groomb. 1359 S.P. .	2	19 38 13·94		+0·04		−0·079
		α Aquilæ.	7	19 42 45·56				
	W	β Aquilæ.	7	19 47 14·38		−0·06	−0·062	
							−0·071	
		Aquilæ (204) Bode	7	19 50 53·77				
		Aquilæ (207) Bode	5	19 53 1·58				
		τ Aquilæ.	7	19 56 6·30				
		θ Aquilæ.	7	20 2 50·65			−0·098	
		α^2 Capricorni	6	20 8 59·30				
		λ Ursæ Minoris	1	20 18 20·65			−0·111	
July 28	E	α Ophiuchi.	6	17 27 15·01		+0·04		−0·129
		β Ophiuchi	3	17 36 19·64				
		γ Ophiuchi	7	17 39 37·79				
		ɣ Ophiuchi	7	17 50 0·18				
		70 Ophiuchi.	7	17 57 7·73			−0·150	
							−0·118	
		72 Ophiuchi.	7	17 59 30·80			−0·112	
		δ Ursæ Minoris.	4	18 22 14·81				
		Cephei 51 (Hev.) S.P.	2	18 24 54·63				
	W	δ Ursæ Minoris	3	18 22 15·30		−0·06	−0·132	
		Cephei 51 (Hev.) S.P.	2	18 24 55·61			−0·140	
		6 Aquilæ	7	18 38 27·70				
		β Lyræ	7	18 43 52·38				
		ε Aquilæ.	7	18 52 6·09				
		Piazzi VI. 292 S.P.	1	18 57 21·44				
		ζ Aquilæ.	6	18 57 47·58				
		19 Aquilæ.	5	19 0 54·66				
		*N.P.D. 6°. 19′ . . .	5	19 11 36·09				
		δ Aquilæ.	7	19 17 11·26				
		μ Aquilæ	7	19 26 1·70				
		γ Aquilæ	5	19 38 24·09				
		α Aquilæ	7	19 42 43·88				
		β Aquilæ	7	19 47 12·54				
		θ Aquilæ.	6	20 2 48·55				
		λ Ursæ Minoris	1	20 18 21·65			−0·121	
		α Cygni	7	20 35 40·12				
July 29					+0·06			
July 30	E	δ Ursæ Minoris	3	18 22 12·24		+0·04	−0·174	−0·156
		9 Aquilæ	7	18 48 13·03				
		ε Aquilæ.	7	18 52 2·95				
		Piazzi VI. 292 S.P.	1	18 52 19·29				
		ζ Aquilæ.	7	18 57 44·76				
	W	21 Aquilæ.	6	19 5 21·32		−0·06		
		22 Aquilæ.	7	19 8 18·23				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f''	*f''*	*f''*	s	s	s		s	h m	s
	+0·16	+0·16	15·25	43·89	+28·64	J H	0·00		
			45·65	14·16	+28·51				
			14·39	42·92	+28·53				
			53·82	22·44	+28·62	G	−0·04		
			1·57	29·97	+28·40				
			6·31	35·06	+28·75				
			50·67	19·28	+28·61	J H	0·00		
			59·36	28·01	+28·65				
	+0·16		9·83	38·62	+28·79			20 24	+28·58
		+0·22	15·10	45·16	+30·06				
			19·76	49·71	+29·95	G	−0·04		
			37·92	8·01	+30·09	J H	0·00		
			0·36	30·35	+29·99				
			7·86	38·08	+30·22				
			30·90	1·05	+30·15			18 2	+30·18
	+0·27		11·62	41·86	+30·24				
			58·79	32·24	+33·45	S	−0·33		
			10·43	41·86	+31·43	J H	0·00		
	+0·27		1·85	32·24	+30·39	S	−0·33		
			27·76	57·89	+30·13	J H	0·00		
			52·26	22·69	+30·43				
			6·07	36·30	+30·23				
	+0·18		23·84	54·70	+30·86	S	−0·33		
	+0·21								
			47·57	18·15	+30·58				
			54·67	25·41	+30·74				
	+0·18		33·52	4·80	+31·28				
			11·29	41·89	+30·60				
			1·71	32·02	+30·31	G	−0·04		
			24·09	54·50	+30·41				
			43·89	14·16	+30·27				
			12·55	42·93	+30·38				
			48·59	19·29	+30·70	S	−0·33		
	+0·21		7·06	38·32	+31·26				
			39·91	10·75	+30·84				
x+0·02									
x+0·02								12 14	+31·37
	+0·30	+0·30	7·93	41·36	+33·43	J H	0·00		
			13·25	46·60	+33·35				
			3·06	36·29	+33·23				
	+0·30		21·50	54·93	+33·43				
			44·88	18·15	+33·27				
			21·39	54·74	+33·35				
			18·31	51·73	+33·42				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	f″	f″	f″	f″
July 30	W	26 Aquilæ	7	19 11 43·98		−0·06		−0·156
		δ Aquilæ	7	19 17 8·52				
		36 Aquilæ	7	19 22 0·88				
		μ Aquilæ	6	19 25 58·63				
		σ Aquilæ	7	19 30 59·97			−0·137	
		γ Aquilæ	7	19 38 21·02				
		α Aquilæ	6	19 42 40·81				
		β Aquilæ	7	19 47 9·48				
July 31					0·00		−0·173	
							−0·166	
Aug. 1		Polaris S.P.	1	13 3 9·55	+ 0·06		−0·241	−0·241
	E	Capella	6	5 4 37·28		+0·04	−0·214	−0·235
		α Orionis	7	5 46 9·09			−0·204	
Aug. 2	W	ε Ursæ Minoris	4	17 1 35·60		−0·06	−0·324	
							−0·201	
Aug. 4	E	Groomb. 1004 S.P.	2	17 42 28·90	+ 0·06	+0·04		−0·145
		70 Ophiuchi	4	17 56 58·08				
		72 Ophiuchi	7	17 59 20·97			−0·122	
		δ Ursæ Minoris	7	18 22 5·00			−0·118	
		3 Aquilæ	7	18 34 25·50				
		6 Aquilæ	7	18 38 17·87				
		β Lyræ	7	18 43 42·88				
		9 Aquilæ	7	18 48 6·52				
		ε Aquilæ	7	18 51 56·30				
	W	Piazzi VI. 292 S.P.	2	18 57 14·09		−0·06		
		ζ Aquilæ	7	18 57 38·08				
		21 Aquilæ	6	19 5 14·75				
		22 Aquilæ	7	19 8 11·54				
		26 Aquilæ	7	19 11 37·20				
		δ Aquilæ	7	19 17 1·85				
		36 Aquilæ	7	19 21 54·28				
		μ Aquilæ	7	19 25 51·95				
		σ Aquilæ	6	19 30 53·50				
		χ Aquilæ	6	19 34 37·32				
		γ Aquilæ	7	19 38 14·41				
		α Aquilæ	7	19 42 34·18				
		β Aquilæ	7	19 47 2·87				
		θ Aquilæ	7	20 2 39·23				
		λ Ursæ Minoris	2	20 18 9·68			−0·187	
							−0·153	
Aug. 5					+ 0·06			

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		+0·30	44·10	17·27	+33·17	J H	0·00		
			8·59	41·89	+33·30				
			0·98	34·37	+33·39				
			58·68	32·02	+33·34				
			0·04	33·57	+33·53				
			21·05	54·51	+33·46				
			40·85	14·17	+33·32			19 44	+33·37
			9·53	42·94	+33·41				
x+0·06									
x−0·06								12 37	+34·30
x−0·06	+0·19	+0·13	21·88	58·50	+36·62				
x−0·06									
			37·03	13·51	+36·48				
			9·06	45·62	+36·56			5 50	+36·54
								12 48	+36·94
	+0·19		33·15	8·50	+35·35				
								12 48	+39·62
x+0·06	+0·40	+0·26	33·13	14·95	+41·82				
x+0·08									
			58·23	38·04	+39·81				
			21·08	1·00	+39·92				
	+0·40		1·22	40·10	+38·88				
			25·70	5·68	+39·98				
			18·05	57·88	+39·83				
			42·87	22·63	+39·76				
			6·71	46·60	+39·89				
	+0·14		56·39	36·28	+39·89				
			16·80	55·52	+38·72				
			38·08	18·13	+40·05				
			14·80	54·75	+39·95				
			11·59	51·73	+40·14				
			37·28	17·27	+39·99				
			1·90	41·90	+40·00				
			54·35	34·36	+40·01				
			51·98	32·02	+40·04				
			53·54	33·59	+40·05				
			37·33	17·41	+40·08				
			14·42	54·51	+40·09				
			34·20	14·19	+39·99				
			2·90	42·96	+40·06				
			39·30	19·32	+40·02			20 0	+40·02
	+0·14		53·28	36·27	+42·99				
								13 33	+40·82
x+0·03									
x+0·03									

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 8	E	21 Aquilæ	7	19 5 8·59		+0·04		+1·365
		22 Aquilæ	7	19 8 5·69				
		∂ Aquilæ.....	7	19 16 55·93			+1·365	
		β Aquilæ	7	19 46 57·93				+0·092
		λ Ursæ Minoris	1	20 18 11·08			+0·088	
							+0·096	
Aug. 9					+0·05			
Aug. 10					+0·06			
Aug. 13					+0·06		+0·060	
Aug. 14		ε Ursæ Minoris	7	17 1 17·00	+0·05		+0·064	+0·045
		α Ophiuchi.....	7	17 26 54·54			+0·088	
		ο Serpentis.....	7	17 31 52·41				
		β Ophiuchi.....	4	17 34 59·23				
		γ Ophiuchi.....	7	17 39 17·40				
		Groomb. 1004 S.P..	2	17 42 29·59				
		ν Ophiuchi	3	17 49 38·55				
	W	∂ Ursæ Minoris	1	18 21 46·58		−0·06		
		24 Ursæ Minoris ...	1	18 27 35·87				
		6 Aquilæ.....	7	18 38 7·47				
		β Lyræ	7	18 43 32·08				
		9 Aquilæ.....	7	18 47 56·16				
		ε Aquilæ.....	7	18 51 45·76				
		Piazzi VI. 292 S.P.	3	18 57 6·32				
		ζ Aquilæ.....	7	18 57 27·63				
		21 Aquilæ	7	19 5 4·16				
		22 Aquilæ	7	19 8 1·30				
		26 Aquilæ	7	19 11 26·85				
		∂ Aquilæ.....	7	19 16 51·55				
		36 Aquilæ	7	19 21 43·94				
		μ Aquilæ	7	19 25 41·55				
		σ Aquilæ	7	19 30 43·03				
		γ Aquilæ	7	19 38 3·96			0·000	
		α Aquilæ	7	19 42 23·73				
		β Aquilæ	7	19 46 52·48				
		θ Aquilæ	6	20 2 28·91			+0·028	
		α^2 Capricorni	7	20 8 37·53				
		β Capricorni.....	7	20 11 28·48				
		λ Ursæ Minoris	1	20 17 43·65				
Aug. 15	E	26 Aquilæ	7	19 11 25·43		+0·04	−0·049	−0·085
		ν Aquilæ.....	7	19 17 44·50			−0·083	

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow Used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		+0·89	10·18	54·73	+44·55	J H	0·00		
			7·44	51·71	+44·27				
			57·53	41·90	+44·37				
	+0·89		58·69	42·96	+44·27				
	+0·89		51·03	35·06	+44·03			20 5	+44·40
								10 40	+45·00
x+0·01									
x+0·01									
x+0·00									
x+0·00								10 55	+49·07
x+0·06									
x+0·04									
	+0·10	+0·04	17·45	6·58	+49·13				
x−0·06			54·65	44·98	+50·33				
x−0·04			52 51	42·95	+50·44				
			59·33	49·54	+50·21				
			17·50	7·85	+50·35				
	+0·10		28·73	18·77	+50·04				
			38·65	30·22	+51·57				
	−0·03		45·83	36·91	+51·08				
	+0·03		35·03	25·31	+50·28				
			7·46	57·81	+50·35				
			32·08	22·53	+50·45				
			56·15	46·55	+50·40				
			45·77	36·21	+50·44				
	−0·03								
	+0·03		6·76	56·86	+50·10				
	+0·04		27·64	18·07	+50·43				
			4·16	54·70	+50·54				
			1·30	51·69	+50·39				
			26·84	17·23	+50·39				
			51·55	41·87	+50·32				
			43·93	34·33	+50·40				
			41·55	31·99	+50·44				
			43·03	33·55	+50·52				
			3·96	54·49	+50·53				
			23·73	14·18	+50·45				
			52·48	42·94	+50·46				
			28·91	19·33	+50·42			20 3	+50·48
			37·53	28·08	+50·55				
			28·48	18·85	+50·37				
	+0·04		41·33	31·56	+50·23				
		−0·04	25·40	17·23	+51·83				
			44·46	36·36	+51·90				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 15	E	36 Aquilæ	5	19 21 42·46		+0·04		−0·085
		μ Aquilæ	7	19 25 40·08				
		σ Aquilæ	6	19 30 41·73				
		χ Aquilæ	7	19 34 25·59				
		γ Aquilæ	7	19 38 2·55				
		α Aquilæ	7	19 42 22·31				
		β Aquilæ	7	19 46 51·12				
		θ Aquilæ.....	7	20 2 27·59				
		α^2 Capricorni	5	20 8 36·23				
		β Capricorni.....	7	20 11 26·97				
		λ Ursæ Minoris	2	20 17 39·52				
	W	ε Delphini.....	7	20 24 57·90		−0·06		
		ζ Delphini.....	7	20 27 13·14				
		β Delphini	7	20 29 26·33				
		α Delphini	7	20 31 35·82				
		75 Draconis.....	4	20 36 59·76				
		ε Aquarii	7	20 38 26·20				
		μ Aquarii.....	7	20 43 26·70			−0·104	
		76 Draconis.....	3	20 52 45·90			−0·105	
							−0·172	
							−0·145	
Aug. 17		Polaris S.P.....	2	13 2 59·90	+ 0·06		−0·120	−0·135
	E	β Aquilæ.....	7	19 46 48·53		+0·04		
		Aquilæ 204 (Bode)..	7	19 50 27·95				
		Aquilæ 207 (Bode)..	6	19 52 35·59			−0·134	
		θ Aquilæ.....	7	20 2 24·87				
		α^2 Capricorni.....	7	20 8 33·50				
		β Capricorni.....	7	20 11 24·59				
		λ Ursæ Minoris	1	20 17 43·35			−0·128	
	W	λ Ursæ Minoris	1	20 17 48·38		−0·06		
		ε Delphini.....	7	20 24 55·49				
		β Delphini	7	20 29 23·68				
		α Delphini	7	20 31 33·15				
		75 Draconis.....	5	20 36 56·98				
		μ Aquarii.....	7	20 43 24·06				
		32 Vulpeculæ.....	7	20 47 4·27				
		76 Draconis.....	3	20 52 44·07			−0·111	
Aug. 18	E	∂ Ursæ Minoris	6	18 21 41·34		+0·04	−0·149	−0·178
		Cephei 51 (Hev.) S.P.	2	18 24 40·60			−0·178	
		β Lyræ.....	7	18 43 26·76				
		9 Aquilæ.....	7	18 47 50·71				
		ε Aquilæ.....	7	18 51 40·41				
		ζ Aquilæ.....	7	18 57 22·35				
	W	Piazzi VI. 292 S.P.	2	18 56 58·85		−0·06		
		21 Aquilæ.....	7	19 4 59·13				
		22 Aquilæ.....	7	19 7 56·03				
		26 Aquilæ.....	7	19 11 21·60				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f''	*f''*	*f''*	s	s	s		s	h m	s
		−0·04	42·42	34·33	+51·91	J H	0·00		
			40·03	31·99	+51·96				
			41·68	33·55	+51·87				
			25·54	17·39	+51·85				
			2·50	54·48	+51·98				
			22·26	14·17	+51·91				
	−0·04		51·07	42·94	+51·87				
			27·55	19·33	+51·78			20 5	+51·89
			36·19	28·08	+51·89				
			26·94	18·86	+51·92				
	−0·04		39·22	31·07	+51·85				
			57·75	49·61	+51·86				
			12·98	4·87	+51·89				
			26·17	17·99	+51·82				
			35·66	27·51	+51·85				
			59·02	50·89	+51·87				
			26·06	17·95	+51·89				
			26·56	18·42	+51·86				
			45·08	36·93	+51·85				
x−0·29									
x−0·18	+0·26	+0·14	9·34	9·70	+60·36			11 55	+53·93
x−0·06									
x−0·04			48·58	42·93	+54·35				
			28·06	22·46	+54·40				
			35·63	29·99	+54·36				
			24·94	19·32	+54·38				
			33·62	28·08	+54·46				
			24·71	18·86	+54·15				
			35·82	30·23	+54·41				
	+0·26		35·87	30·23	+54·36				
			55·43	49·60	+54·17				
			23·60	17·99	+54·39				
			33·07	27·51	+54·44				
			55·44	50·79	+55·35				
			24·07	18·44	+54·37				
			4·17	58·65	+54·48				
			42·31	36·83	+54·52			20 50	+54·40
	+0·06	−0·05	39·96	35·68	+55·72				
	+0·06		41·98	40·09	+58·11				
			26·58	22·48	+55·90				
			50·62	46·52	+55·90				
			40·28	36·17	+55·89				
			22·22	18·04	+55·82				
	−0·15		0·06	57·45	+57·39				
			58·92	54·67	+55·75				
			55·80	51·66	+55·86				
			21·41	17·21	+55·80				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 15	E	36 Aquilæ	5	19 21 42·46		+0·04		−0·085
		μ Aquilæ	7	19 25 40·08				
		σ Aquilæ	6	19 30 41·73				
		χ Aquilæ	7	19 34 25·59				
		γ Aquilæ	7	19 38 2·55				
		α Aquilæ	7	19 42 22·31				
		β Aquilæ	7	19 46 51·12				
		θ Aquilæ	7	20 2 27·59				
		α^2 Capricorni	5	20 8 36·23				
		β Capricorni	7	20 11 26·97				
		λ Ursæ Minoris	2	20 17 39·52				
	W	ε Delphini	7	20 24 57·90		−0·06		
		ζ Delphini	7	20 27 13·14				
		β Delphini	7	20 29 26·33				
		α Delphini	7	20 31 35·82				
		75 Draconis	4	20 36 59·76				
		ε Aquarii	7	20 38 26·20				
		μ Aquarii	7	20 43 26·70			−0·104	
		76 Draconis	3	20 52 45·90			−0·105	
							−0·172	
							−0·145	
Aug. 17		Polaris S.P.	2	13 2 59·90	+ 0·06		−0·120	−0·135
	E	β Aquilæ	7	19 46 48·53		+0·04		
		Aquilæ 204 (Bode)	7	19 50 27·95				
		Aquilæ 207 (Bode)	6	19 52 35·59			−0·134	
		θ Aquilæ	7	20 2 24·87				
		α^2 Capricorni	7	20 8 33·50				
		β Capricorni	7	20 11 24·59				
		λ Ursæ Minoris	1	20 17 43·35			−0·128	
	W	λ Ursæ Minoris	1	20 17 48·38		−0·06		
		ε Delphini	7	20 24 55·49				
		β Delphini	7	20 29 23·68				
		α Delphini	7	20 31 33·15				
		75 Draconis	5	20 36 56·98				
		μ Aquarii	7	20 43 24·06				
		32 Vulpeculæ	7	20 47 4·27				
		76 Draconis	3	20 52 44·07			−0·111	
Aug. 18	E	δ Ursæ Minoris	6	18 21 41·34		+0·04	−0·149	−0·178
		Cephei 51 (Hev.) S.P.	2	18 24 40·60			−0·178	
		β Lyræ	7	18 43 26·76				
		9 Aquilæ	7	18 47 50·71				
		ε Aquilæ	7	18 51 40·41				
		ζ Aquilæ	7	18 57 22·35				
	W	Piazzi VI. 292 S.P.	2	18 56 58·85		−0·06		
		21 Aquilæ	7	19 4 59·13				
		22 Aquilæ	7	19 7 56·03				
		26 Aquilæ	7	19 11 21·60				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		−0·04	42·42	34·33	+51·91	J H	0·00		
			40·03	31·99	+51·96				
			41·68	33·55	+51·87				
			25·54	17·39	+51·85				
			2·50	54·48	+51·98				
			22·26	14·17	+51·91				
	−0·04		51·07	42·94	+51·87				
			27·55	19·33	+51·78			20 5	+51·89
			36·19	28·08	+51·89				
			26·94	18·86	+51·92				
	−0·04		39·22	31·07	+51·85				
			57·75	49·61	+51·86				
			12·98	4·87	+51·89				
			26·17	17·99	+51·82				
			35·66	27·51	+51·85				
			59·02	50·89	+51·87				
			26·06	17·95	+51·89				
			26·56	18·42	+51·86				
			45·08	36·93	+51·85				
x−0·29									
x−0·18	+0·26	+0·14	9·34	9·70	+60·36			11 55	+53·93
x−0·06			48·58	42·93	+54·35				
x−0·04			28·06	22·46	+54·40				
			35·63	29·99	+54·36				
			24·94	19·32	+54·38				
			33·62	28·08	+54·46				
			24·71	18·86	+54·15				
			35·82	30·23	+54·41				
	+0·26		35·87	30·23	+54·36				
			55·43	49·60	+54·17				
			23·60	17·99	+54·39				
			33·07	27·51	+54·44				
			55·44	50·79	+55·35				
			24·07	18·44	+54·37				
			4·17	58·65	+54·48				
			42·31	36·83	+54·52			20 50	+54·40
	+0·06	−0·05	39·96	35·68	+55·72				
	+0·06		41·98	40·09	+58·11				
			26·58	22·48	+55·90				
			50·62	46·52	+55·90				
			40·28	36·17	+55·89				
			22·22	18·04	+55·82				
	−0·15		0·06	57·45	+57·39				
			58·92	54·67	+55·75				
			55·80	51·66	+55·86				
			21·41	17·21	+55·80				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. E. d East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 18	W	ϑ Aquilæ.....	7	19 16 46·32		−0·06	−0·242	−0·178
		μ Aquilæ.....	6	19 25 36·39				
		σ Aquilæ	7	19 30 37·92			−0·072	
		γ Aquilæ.....	6	19 37 58·62				
		α Aquilæ.....	7	19 42 18·56				
		β Aquilæ	7	19 46 47·29			−0·226	
		θ Aquilæ.....	7	20 2 23·60			−0·201	
		α^2Capricorni.....	7	20 8 32·24				
		β Capricorni.....	7	20 11 23·07				
		λ Ursæ Minoris....	1	20 17 37·65				
Aug. 20	E	ϑ Aquilæ.....	7	19 16 42·67	+0·06	+0·04	−0·272	−0·200
		36 Aquilæ	7	19 21 35·07			−0·129	
		μ Aquilæ	7	19 25 32·84				
		χ Aquilæ	7	19 34 18·28				
		γ Aquilæ.....	5	19 37 55·29				
		α Aquilæ	7	19 42 14·94				
		β Aquilæ	7	19 46 43·77				
		Aquilæ 207 (Bode)..	7	19 52 30·94				
		θ Aquilæ.....	7	20 2 20·18				
		75 Draconis.....	2	20 36 54·12				
Aug. 21					+0·06			
Aug. 22					+0·06			
Aug. 24		Polaris S.P.....	4	13 3 7·52	+0·06		−0·124	−0·092
							−0·130	
		ε Ursæ Minoris	7	17 1 1·41				
		α Ophiuchi.....	7	17 26 40·35			−0·022	
		o Ophiuchi.....	7	17 31 38·28			−0·045	
		β Ophiuchi.....	7	17 34 44·96				
		γ Ophiuchi	7	17 39 3·35				
		Groomb. 1004 S.P..	2	17 42 22·09				
		70 Ophiuchi	7	17 56 33·53				
		72 Ophiuchi	7	17 58 56·15				
		ϑ Ursæ Minoris....	1	18 21 30·52				
	W	α^2Capricorni.....	5	20 8 23·74		−0·06	−0·198	
		β Capricorni.....	6	20 11 14·57			−0·036	
Aug. 25					+0·11			
Aug. 27		α Ophiuchi.....	7	17 26 35·16	+0·07			+0·061

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f''	*f''*	*f''*	s	s	s		s	h m	s
		−0·05	46·11	41·83	+55·72	J H	0·00		
			36·16	31·97	+55·81				
			37·70	33·53	+55·83				
			58·39	54·46	+56·07				
			18·33	14·15	+55·82				
			47·07	42·92	+55·85				
			23·40	19·32	+55·92				
			32·06	28·08	+56·02				
			22·89	18·86	+55·97				
	−0·15		28·89	29·87	+60·98			20 23	+55·94
x−0·18									
x−0·18									
x−0·06		+0·13	42·68	41·82	+59·14				
x−0·06									
			35·11	34·31	+59·20				
			32·83	31·95	+59·12				
			18·26	17·36	+59·10				
			55·27	54·45	+59·18				
			14·93	14·14	+59·21				
	+0·52		43·77	42·92	+59·15				
			30·93	29·97	+59·04				
			20·21	19·32	59·11				
	+0·52		52·87	50·63	+57·76			20 28	+59·19
x−0·06									
x−0·06								12 43	+60·10
x−0·12									
x−0·12									
x−0·12	+0·08	+0·07	10·34	14·46	+64·12				
x−0·12									
	+0·08		0·86	4·85	+63·99				
			40·37	44·84	+64·47				
			38·24	42·81	+64·57				
			44·99	49·42	+64·43				
			3·38	7·72	+64·34				
	−0·16		23·43	22·90	+59·47				
			33·56	37·82	+64·26				
			56·17	0·77	+64·60				
	−0·16		29·24	33·47	+64·23			18 26	+64·45
			23·71	28·05	+64·34				
			14·54	18·84	+64·30				
x−0·29									
x−0·18								14 1	+65·71
x+0·06									
x+0·08		+0·24	35·31	44·80	+69·49	S	−0·33		

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	f″	f″	f″	f″
Aug. 27	W	β Ophiuchi	4	17 34 39·92		−0·06		+0·061
		γ Ophiuchi.....	5	17 38 58·26				
		Groomb. 1004 S.P..	1	17 42 11·62				
		70 Ophiuchi.....	7	17 56 28·58				
		72 Ophiuchi.....	7	17 58 51·40			+0·060	
		δ Ursæ Minoris	4	18 21 25·57			+0·054	
	E	δ Ursæ Minoris.....	3	18 21 24·37		+0·04		
		Cephei 51 (Hev.) S.P.	2	18 24 34·38				
		β Lyræ.....	7	18 43 13·08				
		9 Aquilæ	7	18 47 36·99				
		ε Aquilæ	7	18 51 26·69				
		Piazzi VI. 292 S.P.	3	18 56 49·94				
		ζ Aquilæ	7	18 57 9·13				
		21 Aquilæ	6	19 4 45·15				
		δ Aquilæ.....	7	19 16 32·33				
		36 Aquilæ	7	19 21 24·66			+0·061	
		γ Aquilæ.....	7	19 37 45·01			+0·071	
		α Aquilæ	7	19 42 4·67				
Aug. 28		26 Aquilæ	7	19 11 6·07				+0·070
		δ Aquilæ.....	7	19 16 30·78				
		36 Aquilæ	6	19 21 23·13				
		μ Aquilæ.....	7	19 25 20·87				
		σ Aquilæ	7	19 30 22·44				
		χ Aquilæ.....	7	19 34 6·19				
		γ Aquilæ.....	7	19 37 43·38				
		α Aquilæ.....	7	19 42 3·17				
		β Aquilæ.....	7	19 46 31·77			+0·075	
		θ Aquilæ	7	20 2 8·28			+0·070	
		α^2 Capricorni	6	20 8 16·96				
		β Capricorni.....	7	20 11 7·82				
		λ Ursæ Minoris	1	20 17 14·35				
	W	λ Ursæ Minoris	1	20 17 20·88		−0·06		
		ε Delphini.....	3	20 24 38·54				
		β Delphini	7	20 29 6·96				
		α Delphini	7	20 31 16·46				
		75 Draconis.....	4	20 36 39·31				
		ε Aquarii	7	20 38 6·96				
		μ Aquarii.....	7	20 43 7·30				
		32 Vulpeculæ.....	7	20 46 47·62			+0·085	
							+0·050	
Aug. 29					+ 0·06			
Aug. 30	E	ε Ursæ Minoris	4	17 0 51·13		+0·04		+0·058
		α Ophiuchi.....	7	17 26 30·84				
		ε Serpentis.....	7	17 31 28·69				

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
x+0·06		+0·24	40·08	49·37	+69·29	S	−0·33		
x+0·06			58·43	7·68	+69·25				
	+0·28		14·58	24·20	+69·62				
			28·75	37·78	+69·03	J H	0·00		
			51·55	0·73	+69·18			18 7	+69·05
	+0·23		23·20	32·34	+69·14				
	+0·20								
	+0·28		23·68	32·34	+68·66				
	+0·23		35·75	44·41	+68·66				
			13·29	22·33	+69·04				
			37·27	46·43	+69·16				
			26·93	36·06	+69·13				
	+0·20		50·60	58·91	+68·31				
			9·38	17·94	+68·56				
			45·42	54·59	+69·17				
			32·60	41·77	+69·17				
			24·93	34·24	+69·31				
			45·27	54·40	+69·13				
			4·92	14·09	+69·17				
		+0·25	6·37	17·11	+70·74			19 7	+70·72
			31·05	41·76	+70·71				
			23·42	34·23	+70·81				
			21·14	31·88	+70·74				
			22·72	33·46	+70·74				
			6·45	17·29	+70·84				
			43·65	54·39	+70·74				
			3·44	14·08	+70·64				
			32·05	42·86	+70·81				
			8·57	19·27	+70·70				
	+0·27		17·27	28·03	+70·76				
			8·13	18·82	+70·69				
			11·94	23·02	+71·08				
	+0·27		13·49	23·02	+69·53				
			38·70	49·56	+70·86				
			7·12	17·95	+70·83				
			16·62	27·46	+70·84				
			38·59	50·08	+71·49				
			7·16	17·94	+70·78				
			7·50	18·41	+70·91				
			47·77	58·61	+70·84				
x+0·06									
x+0·06								11 38	+71·81
	+0·16	+0·16	51·23	3·79	+72·56				
			31·04	44·74	+73·70				
			28·90	42·73	+73·83				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 30	E	β Ophiuchi.....	6	17 34 35·40		+0·04		+0·058
		γ Ophiuchi	7	17 38 53·66				
		Groomb. 1004 S.P..	2	17 42 12·59				
		ν Ophiuchi	7	17 49 16·02				
		70 Ophiuchi.....	7	17 56 23·64			+0·056	
		72 Ophiuchi.....	7	17 58 46·50			+0·024	
	W	δ Ursæ Minoris.....	6	18 21 18·85		−0·06	+0·073	
		Cephei 51 (Hev.) S.P.	3	18 24 28·68				
		β Lyræ	7	18 43 8·42				
		9 Aquilæ	7	18 47 32·31				
		ε Aquilæ.....	7	18 51 21·97				
		ζ Aquilæ.....	7	18 57 4·11				
		Piazzi VI. 292 S.P.	3	18 56 44·65				
		21 Aquilæ.....	7	19 4 40·54				
		22 Aquilæ.....	7	19 7 37·60				
		26 Aquilæ	7	19 11 3·01				
		δ Aquilæ.....	7	19 16 27·67			+0·081	
Aug. 31					+0·06			
Sep. 1	E	72 Ophiuchi.....	7	17 58 43·27		+0·04	+0·074	
		δ Ursæ Minoris	6	18 21 13·24			+0·068	
		Cephei 51 (Hev.) S.P.	2	18 24 27·43				
		β Lyræ.....	7	18 44 4·99				
		9 Aquilæ	6	18 47 29·03				
		ε Aquilæ.....	7	18 51 18·69				
		Piazzi VI. 292 S.P.	3	18 56 43·31				
		ζ Aquilæ.....	6	18 57 0·64				
		21 Aquilæ.....	4	19 4 37·21				
		22 Aquilæ	3	19 7 34·08				
		26 Aquilæ	7	19 10 59·79				
		δ Aquilæ.....	7	19 16 24·61				
	W	36 Aquilæ	7	19 21 17·05		−0·06	+0·051	
		μ Aquilæ	6	19 25 44·53			+0·041	
		σ Aquilæ	7	19 30 16·20				
		χ Aquilæ	2	19 34 0·01				
		γ Aquilæ	7	19 37 37·00				
		α Aquilæ	7	19 41 56·82				
		β Aquilæ	7	19 46 25·64				
		θ Aquilæ.....	7	20 2 1·88				
		α^2 Capricorni.....	7	20 8 10·62				
		λ Ursæ Minoris	1	20 17 7·65				
Sep. 2		Polaris S.P.....	4	13 3 0·41	+0·06		+0·124	+0·117
		Spica	7	13 15 42·74			+0·111	
Sep. 3		κ Ophiuchi.....	6	16 48 59·60	+0·06			+0·041

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		+0·16	35·60	49·32	+73·72	J H	0·00		
			53·86	7·63	+73·77				
	+0·16		12·91	25·49	+72·58				
			16·23	30·01	+73·78				
			23·84	37·74	+73·90				
			46·69	0·68	+73·99				
	+0·18		17·18	31·30	+74·12				
	+0·13								
	+0·18		31·12	45·68	+74·56				
			8·48	22·28	+73·80				
			32·42	46·39	+73·97				
			22·06	36·03	+73·97				
			4·21	17·90	+73·69				
	+0·13		45·66	59·42	+73·76				
			40·64	54·55	+73·91				
			37·71	51·54	+73·83				
x+0·06			3·12	17·09	+73·97			19 13	+73·90
x+0·06			27·77	41·74	+73·97				
		+0·23	43·51	0·65	+77·14				
	+0·23		12·60	30·59	+77·99				
	+0·23		28·73	46·59	+77·86				
			5·19	22·24	+77·05				
			29·30	46·36	+77·06				
			18·93	36·00	+77·07				
	+0·12		43·92	59·77	+75·85				
			0·88	17·88	+77·00				
			37·47	54·53	+77·06				
			34·35	51·51	+77·16				
			0·06	17·07	+77·01				
			24·87	41·71	+76·84				
			17·21	34·19	+76·98				
			14·68	31·83	+77·15				
			16·35	33·41	+77·06				
			0·15	17·25	+77·10				
			37·14	54·35	+77·21				
			56·96	14·04	+77·08				
			25·79	42·82	+77·03				
			2·04	19·24	+77·20				
			10·80	28·00	+77·20				
	+0·12		0·35	20·21	+79·86			20 13	+77·14
x+0·04									
x+0·04	+0·07		4·53	19·11	+74·58			11 2	+78·17
x+0·04	+0·07		42·94	1·09	+78·15				
x+0·04									
x+0·00		+0·19	59·70	20·12	+80·42				
x+0·00									

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Sep. 3	W	ε Ursæ Minoris	3	17 0 46·33		−0·06		+0·041
		α Ophiuchi.....	7	17 26 24·26				
		β Ophiuchi.....	7	17 34 28·93				
		γ Ophiuchi.....	7	17 38 47·17				
		ν Ophiuchi.....	7	17 49 9·53				
		70 Ophiuchi.....	7	17 56 17·20			+0·073	
		72 Ophiuchi.....	7	17 58 40·07			+0·078	
	E	δ Ursæ Minoris	4	18 21 8·90		+0·04		
		Cephei 51 (Hev.) S.P.	1	18 24 24·52				
		β Lyræ.....	7	18 43 1·48				
		9 Aquilæ.....	7	18 47 25·84				
		ε Aquilæ.....	7	18 51 15·37				
		Piazzi VI. 292 S.P..	3	18 56 36·27				
		ζ Aquilæ.....	7	18 56 57·35				
		21 Aquilæ.....	7	19 4 33·84				
		22 Aquilæ.....	4	19 7 30·90				
		26 Aquilæ.....	7	19 10 56·53				
		δ Aquilæ.....	7	19 16 21·14			+0·013	
							+0·001	
Sep. 4					+0·04			
Sep. 6					+0·04			
Sep. 9					+0·08			
Sep. 10								
Sep. 11	W	γ Aquarii.....	7	22 12 8·52		−0·06		+0·027
		51 Aquarii.....	7	22 14 31·84				
		ζ Aquarii.....	7	22 19 20·48				
		*N.P.D. 2°. 42′...	5	22 31 6·38			+0·075	
		η Aquarii.....	7	22 25 52·95			−0·029	
		κ Aquarii.....	7	22 29 13·05				
		ζ Pegasi.....	4	22 32 13·52				
	E	3 Piscium.....	7	22 51 10·30		+0·04		
		α Ursæ Majoris S.P.	4	22 52 31·71				
		α Pegasi.....	7	22 55 32·02				
		γ Piscium.....	3	23 7 37·17				
		Groomb. 4008.....	2	23 2 41·29				
		Groomb. 4009.....	2	23 2 54·01				
		*N.P.D. 11°. 47′ S.P.	4	23 10 21·61				
		κ Piscium.....	7	23 17 28·56				
		9 Piscium.....	2	23 17 47·61			+0·031	
		ι Piscium.....	7	23 30 28·10			+0·031	

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	+0·45	+0·19	45.46	3·06	+77·60	J H	0·00	17 3	+80·26
			24·36	44·67	+80·31				
			29·04	49·25	+80·21				
			47·29	7·57	+80·28				
			9·66	29·95	+80·29				
			17·32	37·67	+80·35				
			40·17	0·62	+80·45				
	+0·14		8·39	29·82	+81·43				
	+0·45		25·57	47·57	+82·00				
			1·65	22·20	+80·55				
			26·06	46·33	+80·27				
			15·56	35·96	+80·40				
	+0·14		36·77	0·13	+83·36				
			57·55	17·85	+80·30				
			34·06	54·49	+80·43				
			31·13	51·49	+80·36				
			56·75	17·04	+80·29				
			21·36	41·69	+80·33				
x−0·02									
x−0·06									
x−0·06									
x−0·02								12 19	+84·12
x−0·12									
x−0·12									
x+0·06									
x+0·12								13 33	+89·65
		+0·28	8·71	40·06	+91·35			22 10	+91·52
			32·04	3·46	+91·42				
			20·67	52·01	+91·34				
	+0·33		2·26	32·95	+90·69				
			53·14	24·60	+91·46				
			13·25	44·81	+91·56				
			13·68	45·27	+91·59				
			10·59	42·18	+91·59				
			32·13	4·00	+91·87				
			32·26	3·91	+91·65				
			37·45	9·05	+91·60				
	+0·14		40·95	13·30	+92·35				
	+0·08		53·67	26·36	+92·69				
	+0·08								
	+0·14		22·35	53·79	+91·44				
	+0·33		28·84	0·47	+91·63				
			47·89	19·59	+91·70				
			28·37	0·02	+91·65				

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TRANSITS OBSERVED AT KINGSTOWN.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Mean of Seven Wires.	Error of Collimation of Middle Wire Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Sep. 12	E				+0·08	+0·04		+0·027
Sep. 13					+0·08			
Sep. 14					+0·08			
Sep. 15	W	Polaris	2	1 2 54·20	+0·08	−0·06		+0·110
		9 Draconis S.P. ...	4	0 52 21·13				
		Groomb. 1960 S.P..	3	0 58 19·02				
		β Ursæ Minoris S.P.	4	2 49 31·32			+0·108	
		Castor	4	7 23 3·36			+0·101	
		Pollux	1	7 34 10·52			+0·120	

COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

The stationary chronometers used at Kingstown were the following:—

Molyneux 2354 a half-seconds box-chronometer, going solar time nearly.

$\frac{1}{2}\Sigma$, a half-seconds box-chronometer, going sidereal time nearly.

Σ, a table-chronometer, beating seconds, going sidereal time.

σ, a small half-seconds chronometer, going sidereal time.

Molyneux 2388, a half-seconds box-chronometer, going sidereal time nearly to July 16 (after which it was altered to go solar time nearly).

House clock, a clock going sidereal time.

Molyneux 1839, a half-seconds box-chronometer, going solar time.

Molyneux 2388, going solar time from July 26.

The whole of these are the property of Mr. Sheepshanks.

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TRANSITS OBSERVED AT KINGSTOWN.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f′*	s	s	s		s	h m	s
x+0·12		+0·28				J H	0·00		
x+0·06									
x+0·18									
x+0·14								12 1	+95·29
x+0·18	+0·35	+0·35	47·79	24·98	+97·19				
x+0·14	+0·34								
	+0·37								
	+0·35		21·93	59·15	+97·22				
	+0·34		20·00	56·96	+96·96				
	+0·37		32·34	9·94	+97·60				
			3·56	41·47	+97·91				
			10·73	48·69	+97·96			7 35	+97·94

COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

The comparisons made among these chronometers and with the transit-clock were very numerous; but in the reductions it was found that a very large proportion of them might have been omitted as unnecessary, a single comparison being (to sense) as accurate as many. In the following table, a single comparison only is taken from each group.

The chronometer 2354 ran down between July 16 and July 20.

The errors on solar time, as has been already explained, are all subject to the same constant correction.

The comparison of 2354 and Σ, which is given for the time, August 15, 10^h, was in reality made at August 14, 22^h; that of 2354 and σ, which is given for July 29, 3^h, was made at July 29, 10^h.

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Approximate Solar Time, 1844.	Time of Transit Clock at Comparison	Corresponding Time of 2354.	2354, Slow.	Time of 2354 at Comparison.	Corresponding Time of $\frac{1}{2}\Sigma$	$\frac{1}{2}\Sigma$ Slow.
d h	h m s	h m s	m s	h m s	h m s	m s
June 27 11	17 33 50	11 31 44·0	−22 15·32	11 55 53·5	18 21 30·0	−23 11·36
27 22	3 45 51	21 42 5·0	−22 14·82	21 56 24·0	4 23 39·0	−23 10·70
28 8	14 47 10	8 41 36·0	−22 14·30	10 41 40·0	17 11 0·5	−23 9·91
30 9	16 12 28	9 58 50·5	−22 12·49	10 44 15·0	17 21 29·0	−23 8·12
July 1 11	17 23 50	11 6 6·5	−22 12·19	11 45 52·0	18 27 12·0	−23 7·14
2 1	6 40 8	0 20 15·0	−22 11·93	0 35 19·0	7 18 45·0	−23 6·47
2 11	18 47 18	12 25 26·5	−22 11·42	12 55 50·5	19 41 18·0	−23 5·80
4 11	17 33 43	11 4 14·0	−22 9·61	12 59 39·0	19 53 0·0	−23 3·66
5 2	10 12 26	3 40 14·0	−22 8·90	3 11 5·0	10 6 46·0	−23 3·21
5 9	16 16 52	9 43 40·5	−22 8·60	9 0 35·5	15 57 14·0	−23 3·02
6 11	18 46 48	12 9 17·0	−22 6·97	12 56 36·0	19 57 50·0	−23 1·50
9 3	9 31 20	2 43 35·0	−22 3·64	2 52 13·0	10 3 38·0	−22 58·77
9 9	17 46 58	10 57 52·0	−22 3·01	10 24 48·5	17 37 28·0	−22 58·33
10 10	17 54 27	11 1 25·0	−22 1·38	10 12 24·0	17 28 58·0	−22 56·71
11 10	18 1 28	11 4 30·0	−21 59·67	10 31 51·0	17 52 25·0	−22 55·22
12 3	9 28 55	2 29 26·0	−21 58·78	2 44 8·0	10 7 22·0	−22 54·55
13 10	16 16 18	9 11 48·0	−21 56·74	9 52 14·5	17 20 36·0	−22 53·09
14 10	17 21 6	10 12 30·5	−21 54·97	9 27 55·5	17 0 10·0	−22 51·81
15 9	16 45 40	9 33 15·5	−21 53·53	10 32 30·0	18 8 52·0	−22 50·62
16 4	16 51 46	9 39 20·5	−21 53·52	5 24 25·5	13 3 54·0	−22 49·82
20 9	16 47 11	9 14 49·5	−21 21·66	7 19 18·5	15 15 18·0	−22 45·39
21 5	12 55 5	5 19 26·5	−21 20·10	5 6 49·0	13 6 24·0	−22 44·32
21 9	16 38 16	9 2 1·0	−21 19·73	12 3 14·5	20 3 58·0	−22 43·96
22 7	15 1 24	7 20 30·5	−21 18·95	7 0 24·5	15 4 15·0	−22 43·47
24 3	13 51 24	6 2 52·5	−21 14·97	6 51 13·5	15 2 57·0	−22 40·78
24 10	20 0 17	12 10 45·5	−21 14·72	12 41 10·0	20 53 51·0	−22 40·58
26 10	19 10 46	11 13 30·5	−21 11·45	13 0 3·0	21 20 41·0	−22 37·98
27 3	12 36 40	4 36 33·0	−21 10·12	3 46 5·0	12 9 9·0	−22 37·30
27 11	20 24 9	12 22 45·5	−21 9·67	12 45 2·5	21 9 35·0	−22 36·74
28 11	18 2 19	9 57 23·0	−21 8·25	10 57 34·0	19 25 45·0	−22 34·87
29 3	12 14 26	4 6 31·0	−21 6·98	3 33 6·5	12 4 1·0	−22 33·64
30 11	19 44 5	11 31 0·5	−21 5·06	11 54 35·0	20 30 49·0	−22 32·33

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Time of 2354 at Comparison.	Corresponding Time of Σ	Σ Slow.	Time of 2354 at Comparison.	Corresponding Time of σ	σ Slow.	Approximate Solar Time, 1844.
h m s	h m s	m s	h m s	h m s	m s	d h
12 21 50·0	18 47 56	−23 36·56	....	....	....	June 27 11
21 9 29·5	3 37 4	−23 37·94	21 13 54·0	3 40 32·0	−22 40·72	27 22
11 45 56·5	18 15 58	−23 40·30	11 52 7·5	18 21 8·0	−22 38·29	28 8
8 6 45·0	14 44 12	−23 47·03	11 2 48·0	17 39 30·5	−22 33·56	30 9
12 6 22·0	18 48 30	−23 51·76	12 9 56·0	18 50 46·0	−22 33·18	July 1 11
0 58 15·0	7 42 32	−23 53·69	0 57 40·0	7 40 34·5	−22 31·28	2 1
13 14 50·5	20 1 11	−23 55·67	13 16 58·0	20 1 53·5	−22 30·33	2 11
13 19 11·5	20 13 36	−24 3·94	13 23 46·0	20 16 34·5	−22 27·19	4 11
3 14 34·5	10 11 19	−24 6·13	....	....	....	5 2
11 44 30·0	18 42 40	−24 7·38	11 43 8·0	18 39 36·0	−22 25·60	5 9
13 19 41·0	20 22 8	−24 10·71	13 18 1·0	20 18 40·5	−22 23·46	6 11
4 36 8·0	11 49 10	−24 18·56	....	....	....	9 3
12 25 11·5	19 39 32	−24 19·42	12 25 59·0	19 38 19·5	−22 19·29	9 9
12 6 35·0	19 24 53	−24 21·83	12 3 23·0	19 19 35·0	−22 16·35	10 10
13 3 56·5	20 26 25	−24 24·58	13 1 32·0	20 21 51·0	−22 15·48	11 10
4 29 12·0	11 54 15	−24 26·17	4 24 15·0	11 47 4·5	−22 13·50	12 3
12 57 10·5	20 27 39	−24 29·49	13 2 39·0	20 30 50·0	−22 11·09	13 10
12 40 40·0	20 15 6	−24 31·46	12 44 9·0	20 16 14·5	−22 10·38	14 10
11 2 30·5	18 40 40	−24 33·15	11 1 20·0	18 37 5·5	−22 9·34	15 9
5 33 35·5	13 14 50	−24 34·29	5 30 37·0	13 9 25·5	−22 8·80	16 4
6 56 4·0	14 53 54	−24 39·69	6 58 0·0	14 53 11·0	−22 0·42	20 9
7 34 26·0	15 36 22	−24 40·80	7 36 40·0	15 35 54·5	−21 58·96	21 5
12 32 30·5	20 35 16	−24 41·13	12 35 0·0	20 35 3·5	−21 58·72	21 9
6 50 24·5	14 56 12	−24 42·13	6 48 3·0	14 51 5·5	−21 57·53	22 7
23 35 55·0	7 48 29	−24 43·47	23 35 33·0	7 45 16·5	−21 53·03	24 3
12 51 55·5	21 6 42	−24 44·30	12 50 54·0	21 2 48·0	−21 51·97	24 10
....	....	....	.....	....	....	26 10
4 13 20·0	12 38 37	−24 45·79	.....	....	....	27 3
13 9 35·0	21 36 21	−24 46·21	13 10 50·0	21 34 37·0	−21 47·01	27 11
9 41 30·0	18 11 40	−24 46·44	9 42 52·0	18 10 0·5	−21 44·72	28 11
10 8 55·0	18 38 7	−24 46·57	10 29 58·0	19 1 9·5	−21 41·77	29 3
12 5 37·0	20 44 8	−24 47·50	12 7 32·0	20 42 55·0	−21 39·19	30 11

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Approximate Solar Time, 1844.	Time of 2354 at Comparison.	Corresponding Time of 2388 (Sidereal).	2388 (Sidereal) Slow.	Time of 2354 at Comparison.	Corresponding Time of House Clock.	House Clock Slow.
d h	h m s	h m s	m s	h m s	h m s	m s
June 27 11	11 36 49·0	18 2 43·5	−23 32·50	11 53 59·5	17 56 24	+0 0·34
27 22	21 42 45·0	4 10 19·5	−23 32·45	21 6 10·5	3 10 4	+0 2·51
28 8	7 54 20·0	14 23 35·5	−23 32·47	10 25 0·0	16 31 2	+0 5·85
30 9	10 56 57·0	17 34 43·0	−23 38·02	10 25 26·0	16 39 12	+0 16·79
July 1 11	11 12 16·0	17 54 3·5	−23 40·16	11 36 15·0	17 54 4	+0 22·29
2 1	0 39 8·0	7 23 9·5	−23 41·35	0 33 29·0	6 53 23	+0 25·22
2 11	12 46 26·0	19 32 28·0	−23 41·86	12 45 38·0	19 7 30	+0 28·01
4 11	11 4 47·0	17 58 30·0	−23 44·63	10 5 0·0	16 34 11	+0 37·52
5 2	1 34 25·0	8 30 32·5	−23 45·64	1 37 6·0	8 8 48	+0 40·31
5 9	8 59 49·0	15 57 10·5	−23 46·14	11 26 10·5	17 59 28	+0 42·11
6 11	12 30 3·0	19 31 59·0	−23 47·89	9 53 50·0	16. 30. 46	+0 46·34
9 3	2 58 18·0	10 10 38·0	−23 52·76	....	....	....
9 9	10 31 41·0	17 45 16·5	−23 53·20	12 8 18·5	18 57 16	+1 0·80
10 10	10 13 54·0	17 31 26·0	−23 54·45	11 40 5·5	18 32 52	+1 5·29
11 10	12 44 12·0	20 6 9·0	−23 56·36	12 37 40·5	19 34 30	+1 10·08
12 3	2 40 34·0	10 4 50·5	−23 57·63	2 46 15·0	9 45 22	+1 12·80
13 10	9 53 16·0	17 22 44·0	−23 59·43	9 58 25·5	17 2 36	+1 18·93
14 10	9 15 15·0	16 48 36·5	−24 0·91	9 30 51·5	16 38 51	+1 23·68
15 9	9 41 33·0	17 18 58·5	−24 2.53	8 19 30·0	15 31 11	+1 28·41
16 4	5 36 36·0	13 17 20·5	−24 3.80	5 36 10·5	12 51 18	+1 33·14
20 9	....	....	....	....	....	....
21 5	....	....	....	....	....	....
21 9	....	....	....	....	....	....
22 7	....	....	....	....	....	....
24 3	....	....	....	....	....	....
24 10	....	....	....	....	....	....
26 10	....	....	....	....	....	....
27 3	....	....	....	....	....	....
27 11	....	....	....	....	....	....
28 11	....	....	....	....	....	....
29 3	....	....	....	....	....	....
30 11	....	....	....	....	....	....

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Time of ½ Σ at Comparison.	Corresponding Time of 1839.	1839, Slow.	Time of Transit Clock or of ½ Σ at Comparison.	Corresponding Time of 2388 (Solar).	2388 (Solar) Slow.	Approximate Solar Time, 1844.
h m s	h m s	m s	h m s	h m s	m s	d h
18 22 18·0	11 56 32·0	−22 5·94	....	....	....	June 27 11
3 53 44·0	21 26 24·0	−22 4·94	....	....	....	27 22
17 16 50·0	10 47 18·0	−22 3·68	....	....	....	28 8
14 42 33·0	8 5 32·5	−21 59·93	....	....	....	30 9
					....	
18 28 39·0	11 47 4·5	−21 57·92	....	....	....	July 1 11
7 21 17·0	0 37 35·5	−21 56·83	....	....	....	2 1
19 40 34·0	12 54 51·0	−21 55·77	....	....	....	2 11
16 50 20·0	9 57 11·5	−21 52·19	....	....	....	4 11
8 26 16·0	1 30 33·5	−21 50·99	....	....	....	5 2
15 59 21·0	9 2 24·0	−21 50·50	....	....	....	5 9
19 54 13·0	12 52 40·5	−21 47·88	....	....	....	6 11
9 35 10·0	2 23 29·0	−21 43·00	....	....	....	9 3
17 38 41·0	10 25 40·5	−21 42·26	....	....	....	9 9
17 33 42·0	10 16 46·0	−21 40·21	....	....	....	10 10
20 4 39·0	12 43 22·0	−21 38·32	....	....	....	11 10
10 13 30·0	2 49 53·5	−21 37·25	....	....	....	12 3
17 23 56·0	9 55 12·0	−21 34·74	....	....	....	13 10
16 50 5·0	9 17 30·0	−21 32·83	....	....	....	14 10
15 58 58·0	8 22 35·0	−21 31·22	....	....	....	15 9
13 1 0·0	5 21 9·5	−21 29·64	....	....	....	16 4
15 0 36·0	7 4 39·0	−21 21·95	....	....	....	20 9
13 14 16·0	5 14 40·0	−21 20·37	....	....	....	21 5
19 35 56·0	11 35 17·5	−21 20·27	....	....	....	21 9
15 5 6·0	7 1 15·5	−21 19·07	....	....	....	22 7
15 5 41·0	6 53 58·0	−21 15·83	....	....	....	24 3
20 53 5·0	12 40 25·0	−21 15·55	....	....	....	24 10
21 23 40·0	13 3 2·5	−21 12·29	19 13 53·0*	10 56 9·0	−0 43·46	26 10
12 7 18·5	3 44 16·0	−21 11·38	12 9 52·0†	3 26 20·5	−0 42·80	27 3
21 15 38·0	12 51 5·5	−21 10·64	18 29 40·0*	10 8 8·0	−0 42·55	27 11
19 29 29·0	11 1 18·0	−21 8·80	19 27 38·0†	10 39 0·0	−0 41·50	28 11
12 34 23·0	4 3 24·0	−21 7·53	12 36 26·0†	3 45 0·0	−0 40·85	29 3
20 30 3·5	11 53 50·0	−21 5·52	....	....	....	30 11

* Time by Transit Clock.

† Time by ½ Σ.

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Approximate Solar Time, 1844.	Time of Transit Clock at Comparison	Corresponding Time of 2354.	2354, Slow.	Time of 2354 at Comparison.	Corresponding Time of $\frac{1}{2}\Sigma$	$\frac{1}{2}\Sigma$ Slow.
d h	h m s	h m s	m s	h m s	h m s	m s
July 31 3	12 37 26	4 21 35·5	−21 4·15	3 10 45·5	11 49 30·0	−22 31·41
Aug. 1 21	5 50 20	21 27 45·0	−21 2·55	21 38 55·5	6 24 38·0	−22 29·12
2 3	12 48 26	4 24 42·5	−21 2·14	3 6 12·0	11 52 48·5	−22 29·04
4 3	12 48 39	4 17 2·5	−20 58·32	2 42 57·5	11 37 25·0	−22 27·00
4 10	20 0 18	11 27 30·5	−20 57·64	11 50 30·0	20 46 28·0	−22 26·65
5 4	13 33 49	4 58 8·0	−20 55·92	3 54 39·5	12 53 17·0	−22 26·19
8 10	20 5 54	11 17 20·5	−20 51·81	9 51 20·0	19 2 49·0	−22 25·23
9 0	10 40 58	1 50 0·5	−20 50·59	23 52 15·0	9 6 3·0	−22 25·00
13 0	10 55 23	1 48 39·5	−20 46·53	0 9 55·5	9 39 36·0	−22 24·27
14 10	20 3 58	10 51 48·0	−20 44·40	11 25 24·0	21 0 54·0	−22 23·90
15 10	20 5 2	10 48 55·5	−20 42·58	9 32 46·0	19 11 55·5	−22 23·61
17 1	11 55 33	2 32 54·0	−20 39·67	0 35 3·0	10 20 39·0	−22 22·59
17 11	20 50 14	11 26 7·5	−20 39·29	11 41 55·0	21 29 21·0	−22 22·49
18 10	20 23 59	10 56 0·5	−20 37·36	11 8 7·0	20 59 25·0	−22 21·55
20 10	20 28 58	10 53 6·5	−20 33·76	11 17 46·0	21 17 0·0	−22 19·26
21 1	12 43 58	3 5 27·0	−20 33·08	1 4 52·0	11 6 22·0	−22 18·79
24 8	18 26 34	8 35 18·0	−20 27·58	6 27 38·0	16 41 53·5	−22 16·15
25 2	14 1 26	4 6 57·0	−20 25·81	2 18 58·5	12 36 31·0	−22 15·70
27 8	18 7 22	8 4 19·0	−20 20·58	7 39 37·0	18 5 59·0	−22 14·05
28 9	19 7 6	8 59 56·5	−20 18·11	11 13 25·0	21 44 21·0	−22 13·72
29 0	11 38 35	1 28 42·5	−20 16·46	23 55 52·0	10 28 54·0	−22 13·12
30 8	19 13 26	8 58 22·0	−20 13·28	9 20 41·5	19 59 15·0	−22 11·90
Sep. 1 9	20 13 34	9 50 27·0	−20 8·72	10 15 14·0	21 1 52·0	−22 9·78
2 0	11 2 34	0 37 2·5	−20 8·84	0 15 28·0	11 4 24·0	−22 9·87
3 7	17 3 50	6 33 24·0	−20 7·34	5 52 33·0	16 46 20·0	−22 7·47
6 0	12 19 57	1 38 30·0	−20 3·70	23 57 7·0	11 1 47·0	−22 5·61
10 1	13 33 48	2 36 27·5	−20 0·41	0 57 37·0	12 18 13·0	−22 2·12
11 11	22 10 28	11 7 47·0	−19 58·60	12 40 34·0	0 7 2·0	−22 0·18
14 0	12 1 9	0 48 19·0	−19 53·74	0 30 58·5	12 7 19·0	−21 58·09
15 20	7 35 24	20 15 27·0	−19 52·38	20 42 37·0	8 26 13·0	−21 56·59

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Time of 2354 at Comparison.	Corresponding Time of Σ	Σ Slow.	Time of 2354 at Comparison.	Corresponding Time of σ	σ Slow.	Approximate Solar Time, 1844.
h m s	h m s	m s	h m s	h m s	m s	d h
3 11 47·0	11 52 48	−24 47·74	3 13 19·0	11 51 10·0	−21 37·49	July 31 3
21 37 8·5	6 25 10	−24 48·40	....	....	....	Aug. 1 21
3 8 30·5	11 57 27	−24 48·66	3 8 53·0	11 54 35·0	−21 34·10	2 3
2 46 29·5	11 43 20	−24 49·42	2 47 0·0	11 40 32·5	−21 31·31	4 3
12 6 30·5	21 4 54	−24 49·52	....	....	....	4 10
3 53 48·0	12 54 49	−24 49·83	....	....	....	5 4
9 52 39·5	19 6 35	−24 51·52	....	....	....	8 10
1 21 49·5	10 38 19	−24 51·69	23 58 59·0	9 11 44·0	−21 20·91	9 0
0 9 15·0	9 41 25	−24 53·87	0 8 19·0	9 36 48·5	−21 13·54	13 0
11 26 43·0	21 4 44	−24 54·69	11 28 54·0	21 3 13·5	−21 12·82	14 10
22 14 29·5	7 54 18	−24 54·91	....	....	....	15 10
0 41 24·0	10 29 34	−24 55·53	0 41 43·0	10 26 7·0	−21 9·48	17 1
11 46 20·0	21 36 20	−24 55·75	11 48 15·0	21 34 28·0	−21 8·43	17 11
11 12 59·0	21 6 52	−24 55·74	11 15 22·0	21 5 26·5	−21 6·85	18 10
11 25 24·5	21 27 17	−24 56·49	11 26 17·0	21 24 16·0	−21 2·85	20 10
1 9 24·5	11 13 33	−24 56·54	1 13 27·0	11 13 41·5	−21 1·88	21 1
6 31 40·5	16 48 38	−24 57·47	6 33 11·0	16 46 9·5	−20 58·23	24 8
2 24 14·5	12 44 30	−24 57·84	2 23 49·0	12 40 3·0	−20 56·41	25 2
10 7 8·0	20 36 39	−24 58·60	10 7 47·0	20 33 10·0	−20 50·50	27 8
12 0 5·0	22 33 54	−24 58·96	....	....	....	28 9
1 17 4·5	11 53 6	−24 59·13	0 4 28·0	10 36 5·5	−20 47·19	29 0
9 38 25·5	20 19 50	−24 59·97	9 39 54·0	20 17 3·0	−20 44·22	30 8
10 9 39·5	20 59 8	−25 1·20	10 11 37·0	20 56 46·0	−20 41·37	Sep. 1 9
0 24 38·0	11 16 28	−25 2·37	0 23 57·0	11 11 26·0	−20 41·49	2 0
9 33 11·5	20 30 30	−25 2·54	9 34 4·0	20 26 58·0	−20 37·89	3 7
23 47 52·5	10 55 30	−25 4·64	23 48 12·0	10 51 19·5	−20 34·59	6 0
0 59 8·5	12 22 49	−25 6·37	1 1 38·0	12 20 44·0	−20 31·46	10 1
13 6 38·0	0 36 17	−25 6·86	13 7 25·5	0 32 26·0	−20 28·24	11 11
0 37 57·5	12 17 29	−25 7·92	0 36 51·5	12 11 39·0	−20 24·10	14 0
20 45 51·0	8 32 40	−25 9·05	20 41 52·0	8 23 54·0	−20 22·70	15 20

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Approximate Solar Time, 1844.	Time of 2354 at Comparison.	Corresponding Time of 2388 (Sidereal).	2388 (Sidereal) Slow.	Time of 2354 at Comparison.	Corresponding Time of House Clock.	House Clock Slow.
d h	h m s	h m s	m s	h m s	h m s	m s
July 31 3	....	....	....	....	....	....
Aug. 1 21	....	....	....	....	....	....
2 3	....	....	....	....	....	....
4 3	....	....	....	....	....	....
4 10	....	....	....	....	....	....
5 4	....	....	....	....	....	....
8 10	....	....	....	....	....	....
9 0	....	....	....	....	....	....
13 0	....	....	....	....	....	....
14 10	....	....	....	....	....	....
15 10	....	....	....	....	....	....
17 1	....	....	....	....	....	....
17 11	....	....	....	....	....	....
18 10	....	....	....	....	....	....
20 10	....	....	....	....	....	....
21 1	....	....	....	....	....	....
24 8	....	....	....	....	....	....
25 2	....	....	....	....	....	....
27 8	....	....	....	....	....	....
28 9	....	....	....	....	....	....
29 0	....	....	....	....	....	....
30 8	....	....	....	....	....	....
Sep. 1 9	....	....	....	....	....	....
2 0	....	....	....	....	....	....
3 7	....	....	....	....	....	....
6 0	....	....	....	....	....	....
10 1	....	....	....	....	....	....
11 11	....	....	....	....	....	....
14 0	....	....	....	....	....	....
15 20	....	....	....	....	....	....

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COMPARISONS OF STATIONARY CHRONOMETERS AT KINGSTOWN.

Time of $\frac{1}{2}\Sigma$ at Comparison.	Corresponding Time of 1839.	1839 Slow.	Time of Transit Clock or of $\frac{1}{2}\Sigma$ at Comparison.	Corresponding Time of 2388 (Solar).	2388 (Solar) Slow.	Approximate Solar Time, 1844.
h m s	h m s	m s	h m s	h m s	m s	d h
11 48 27·0	3 9 43·0	−21 4·56	....	....	....	July 31 3
6 26 45·0	21 41 1·0	−21 1·40	....	....	....	Aug. 1 21
11 53 14·0	3 6 36·5	−21 1·29	....	....	....	2 3
11 34 28·0	2 40 1·0	−20 58·51	....	....	....	4 3
20 45 33·0	11 49 35·5	−20 57·94	....	....	....	4 10
12 55 44·0	3 57 7·0	−20 56·91	....	....	....	5 4
18 59 58·0	9 48 30·0	−20 52·35	....	....	....	8 10
9 5 23·0	23 51 35·5	−20 51·13	....	....	....	9 0
9 34 24·0	0 4 42·5	−20 44·81	....	....	....	13 0
20 59 34·0	11 24 2·5	−20 42·57	....	....	....	14 10
19 7 13·0	9 28 3·0	−20 41·29	....	....	....	15 10
10 28 34·0	0 42 56·5	−20 39·62	....	....	....	17 1
21 32 9·0	11 44 41·5	−20 38·23	....	....	....	17 11
21 1 46·0	11 10 26·5	−20 36·25	....	....	....	18 10
21 18 6·0	11 18 51·5	−20 33·44	....	....	....	20 10
11 8 17·0	1 6 46·0	−20 32·48	....	....	....	21 1
16 42 40·0	6 28 24·0	−20 27·35	....	....	....	24 8
12 37 31·0	2 19 58·5	−20 26·14	....	....	....	25 2
18 4 1·0	7 37 41·0	−20 22·30	....	....	....	27 8
21 44 48·5	11 13 55·0	−20 20·55	....	....	....	28 9
10 29 19·0	23 56 20·0	−20 19·71	....	....	....	29 0
19 58 8·0	9 19 39·5	−20 18·06	....	....	....	30 8
21 0 21·5	10 13 50·0	−20 14·98	....	....	....	Sep. 1 9
11 4 46·0	0 15 56·0	−20 14·92	....	....	....	2 0
16 50 39·0	5 56 56·0	−20 12·07	....	....	....	3 7
10 54 55·0	23 50 20·5	−20 8·16	....	....	....	6 0
12 19 4·0	0 58 29·0	−20 1·59	....	....	....	10 1
0 10 39·0	12 44 11·0	−19 59·14	....	....	....	11 11
10 47 11·0	23 11 5·0	−19 55·24	....	....	....	14 0
8 27 5·0	20 43 29·0	−19 52·51	....	....	....	15 20

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As has been explained, the "chronometer slow," for the times of comparison with travelling chronometers, has been interpolated by simple proportion of times between the "chronometer slow" for the times of groups of transits, and then the following corrections have been applied for change of chronometer rates:—

		d	h		s
2354,	August	5	4,	correction applied	+ 0·08
Σ,	July	12	4,	. . . . .	− 0·06
	July	16	5,	. . . . .	− 0·35
	July	20	10,	. . . . .	− 0·35
	July	24	4,	. . . . .	− 0·06

CORRECTIONS TO THE ERRORS OF TRANSIT CLOCK AT KINGSTOWN, AS SHEWN BY THE

	June 27d 23h	July 2d 2h	July 5d 3h	July 9d 4h	July 12d 4h	July 16d 5h	July 20d 10h	July 21d 6h	July 24d 4h	July 27d 4h	July 29d 4h
	s	s	s	s	s	s	s	s	s	s	s
Transit Clock	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00
2354	−0·03	+0·09	+0·03	+0·17	+0·08	...	...	...	−0·24	−0·12	−0·10
½ Σ	+0·04	−0·11	−0·01	+0·04	−0·01	+0·06	+0·11	+0·14	−0·11	+0·09	−0·31
Σ	−0·06	−0·07	+0·05	+0·10	−0·04	−0·23	−0·17	−0·06	−0·36	...	−0·38
σ	...	(−0·43)	...	...	−0·57	+0·81	−0·46	−0·12	−0·30	...	−0·23
2388 Sidereal	(−0·09)	(+0·16)	+0·01	+0·13	+0·31	...	...	...	...	...	...
House Clock	+0·06	(−0·07)	(+0·02)	...	+0·04	...	...	...	...	...	...
1839	+0 03	−0·01	−0·07	+0·09	+0·05	−0·02	−0·44	−0·37	−0·10	+0·11	−0·13
2388 Solar	...	...	...	...	...	...	...	...	...	+0·02	...
Mean, or Correction for Transit Clock	+0·01	−0·02	0·00	+0·11	+0·02	+0·05	−0·16	−0·08	−0·18	+0·02	−0·19

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Then the excess of this corrected interpolated "chronometer slow" above the "chronometer slow" found from the comparison, is taken as a correction which, so far as that chronometer indicates, ought to be applied to "Transit Clock Slow." They are collected in the following table, and their means taken. The results of 2354 for August 29 and September 2, those of σ for July 2, August 21, and August 25, those of 2388 for June 27 and July 2, and those of House Clock for July 2 and July 5, are rejected on account of the unsteadiness of rates about those times, and generally only half weight is given to the results of $\frac{1}{2}\sigma$. The results are as follows:—

ADOPTED IN THE REDUCTION OF COMPARISONS OF TRAVELLING CHRONOMETERS,

DIFFERENT STATIONARY CHRONOMETERS.

July 31d 4h	August 2d 4h	August 4d 4h	August 5d 5h	August 9d 1h	August 13d 1h	August 17d 2h	August 21d 2h	August 25d 3h	August 29d 1h	Sep. 2d 1h	Sep. 6d 1h	Sep. 10d 2h	Sep. 14d 1h
s	s	s	s	s	s	s	s	s	s	s	s	s	s
0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00
−0·18	+0·11	+0·13	−0·60	−0·42	+0·42	−0·17	+0·39	+0·14	(−0·01)	(+0·58)	−0·65	+0·39	−1·19
−0·16	+0·14	+0·06	−0·16	−0·18	+0·03	−0·20	+0·05	+0·09	−0·16	+0·84	+0·56	+0·62	−1·03
0·00	+0·12	0·00	−0·04	−0·17	−0·11	−0·10	−0·07	+0·04	−0·12	+0·77	+0·67	+0·35	−0·20
...	...	...	...	...	...	...	(−0·21)	(+0·21)	...	+1·19	−0·23	+1·63	−0·96
...	...	...	...	...	...	...	...	...	...	...	...	...	...
...	...	...	...	...	...	...	...	...	...	...	...	...	...
−0·09	+0·20	+0·02	+0·06	−0·35	−0·16	−0·06	−0·01	+0·16	−0·12	+0·90	+0·36	+0·10	−0·16
...	...	...	...	...	...	...	...	...	...	...	...	...	...
−0·09	+0·11	+0·04	−0·15	−0·22	+0·04	−0·11	+0·07	+0·05	−0·10	+0·69	+0·15	+0·41	−0·38

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VII.—*Transits at Valentia, Personal Equations, Instrumental Errors, Clock Stars, First Results for Clock Errors, and Results as amended by the Comparison of Stationary Chronometers.*

In the beginning of Section VI. it has been mentioned that by comparisons made at Kingstown, personal equations were found, from which the following may be deduced:—

Clock Slow, G — Clock Slow, S = − 0ˢ·29.

As Mr. Sheepshanks and Lieutenant Gosset were the only observers at Valentia, this equation alone is sufficient. The number of observations by Lieutenant Gosset being far greater than that by Mr. Sheepshanks, it was thought expedient to reduce all the results to Lieutenant Gosset's method of observing.

The weather at Valentia, during the whole continuance of the observations, was excessively bad, and nothing but the most constant vigilance on the part of Lieutenant Gosset could have secured the necessary number of observations. Among those obtained, comparatively few were complete transits on the seven wires. It was thought convenient, therefore, to reduce all transits, perfect or imperfect, to transits over the central wire (instead of the mean of the seven wires as at Greenwich and at Kingstown).

The error of collimation was ascertained by noting the apparent position of the middle wire in reversed positions of the transit, as seen upon the meridian mark, and noting the error from bisection as estimated in thicknesses of the middle wire. This wire was measured by Mr. Simms, after the return of the instrument to London, and its thickness was found to be $0^{f''}\cdot16$. From the observations thus computed, the following errors, illuminated end East, were inferred:—

	f''
August 7 and 8	− 0·01
August 10 to 24	− 0·15
August 29 to September 12 . . .	− 0·03

It was thought prudent at Valentia to combine with these the results from circumpolar stars, as obtained from reversing the instrument during the star's passage. As obtained simply from the times at the wires, they are as follows:—

August 17 by δ Ursæ Minoris	− 0ˢ·256
18 .. δ Ursæ Minoris	− 0·260
29 .. λ Ursæ Minoris	− 0·219
30 .. λ Ursæ Minoris	− 0·066
31 .. λ Ursæ Minoris	− 0·230

But on each of these days, except August 29, the azimuthal screws were used,

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so that, both before and after reversion, the wire was made to bisect the south meridian mark. The real errors of collimation are, therefore, on these days only about ½ of those given above. Upon the whole, applying $-0^{s}\cdot01$ for diurnal aberration, the following numbers were adopted:—

	Illuminated End East.	Illuminated End West.
	s''	s''
August 7 and 8	$-0\cdot02$	$0\cdot00$
August 10 to 24	$-0\cdot22$	$+0\cdot20$
August 29 to September 12	$-0\cdot12$	$+0\cdot10$

I think it likely that these numbers are too large; but the effect of the error will be totally insignificant.

The level is not furnished with a cross-level for adjustment of its position when placed on the transit-pivots. But I am assured by Mr. Simms, that great care had been used in fixing the glass bubble within its brass case, so as to render extreme delicacy of position unnecessary. Each end of the level carries a pin, projecting in a direction parallel to the axis of the level; and the position of the level was defined by making one of these pins to pass between the forks of a vertical crutch attached to one of the transit piers. On August 18, in consequence of some unsatisfactory appearance in the level, the position of the crutch was so altered that the level when placed with either pin in it had no tendency to lean either north or south; and thus the level determinations were freed from the possibility of a constant error which might have affected them before. On two or three occasions there seemed (to Lieutenant Gosset's watchful eye) to be some appearance of unsteadiness, and the level was then immediately applied several times; but I do not see anything injurious to the credit of the results. The difference of pivots is apparently insensible.

The azimuthal errors were found as at Kingstown. The meridian mark was fixed rather hastily, and was not placed so near the meridian as was desirable, but near enough for perfect accuracy. The value of x, the azimuthal error of the meridian mark, was found from the mean of all the deductions to be $-5^{s}\cdot30$. The results for separate sections were: to August 17, $-5^{s}\cdot32$; August 18 to September 3, $-5^{s}\cdot33$; September 8 to September 12, $-5^{s}\cdot22$, shewing that the the mark had not sensibly moved.

The transit-clock is a good clock, with gridiron-pendulum, the property of the Ordnance Department.

Before the observations of August 24, the clock was advanced 1^{m}; and before the observations of Polaris, September 8, it was advanced 2^{m}. In winding up, before α Ophiuchi, September 8, it lost 28^{s}.

On August 7, the clock-errors are unsteady; but I can give no explanation of the cause.

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	s″	s″	s″	s″
Aug. 7	E	ε Ophiuchi.....	5	10 9 54·23		−0·02		−0·159
					−0·01		+0·161	
							+0·257	
	W	ζ Ophiuchi.....	7	16 28 24·94		0·00		+0·218
							+0·151	
		ι Ophiuchi.....	7	16 46 25·94				
		κ Ophiuchi.....	7	16 50 5·29				
		ε Ursæ Minoris	3	17 1 29·29				
		Groomb. 944 S.P...	3	17 13 12·89				
		ο Serpentis.....	3	17 32 30·10				
		γ Ophiuchi.....	2	17 39 53·69				
		ν Ophiuchi.....	4	17 50 17·19				
							+0·063	
							+0·120	
							+0·124	
							+0·123	
							+0·187	
							+0·067	
Aug. 8		Polaris S.P.....	2	13 6 7·35			+0·107	+0·117
							−0·002	
Aug. 10		Polaris S.P.....	2	13 5 59·79	−0·24	+0·20	+0·029	+0·008
							0·000	
		ν Ophiuchi.....	4	17 50 9·90				
		70 Ophiuchi	7	17 57 16·40				
		72 Ophiuchi	4	17 59 38·79				
							+0·008	
							−0·028	
		δ Ursæ Minoris	3	18 21 16·86				
							+0·079	
Aug. 11								
Aug. 15		Polaris S.P.....	1	13 5 44·00	0·00		+0·040	+0·048
		Spica	7	13 16 30·16				
Aug. 17		Polaris S.P.....	3	13 5 43·35			−0·048	−0·043
							−0·043	
		β^1 Scorpii.....	5	15 55 50·93				+0·030
							0·000	
		ζ Ophiuchi.....	3	16 28 2·49				
		ι Ophiuchi.....	5	16 46 4·30				
							+0·040	
		ε Ursæ Minoris	4	17 1 5·37				
		Groomb. 944 S.P...	2	17 12 53·73			+0·028	
							+0·085	
		72 Ophiuchi.....	3	17 59 23·95				+0·107
							+0·108	
		δ Ursæ Minoris.....	3	18 20 57·66			+0·087	

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
x—0·05		—5·35	49·84	7·67	+17·83	S	—0·29		
x—0·05									
x—0·01			20·22	38·04	+17·82				
		—5·29	22·56	41·01	+18·45				
			1·84	20·54	+18·70				
	—5·29		50·66	7·73	+17·07				
	—5·29		28·85	45·99	+17·14			17 16	+17·90
			25·30	43·02	+17·72	G	0·00		
x+0·03	—5·85		49·82	7·93	+18·11				
			12·56	30·28	+17·72				
	—5·85	—5·85	43·60	3·96	+20·36			11 7	+19·75
	—5·48	—5·54	39·10	5·42	+26·32				
			5·13	30·26	+25·13				
			12·40	37·99	+25·59				
			35·22	0·94	+25·72				
x—0·15									
x—0·33	—5·48		13·49	38·25	+24·76			18 49	+25·56
								14 27	+27·31
x—0·15	—5·09	—5·47	23·83	8·48	+44·65			12 24	+35·71
x—0·19									
	—5·09		25·46	1·25	+35·79				
x—0·15	—5·31	—5·45	26·30	9·70	+43·40				
x—0·47	—5·31		45·68	26·10	+40·42				
x—0·15			57·79	37·91	+40·12				
			0·85	40·87	+40·02				
	—5·23		27·62	6·08	+38·46				
	—5·23		7·69	48·75	+41·06				
x—0·15			20·51	0·87	+40·36				
	—5·53		54·80	35·99	+41·19				

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 17	E	δ Ursæ Minoris.....	2	18 21 6·26	−0·12	−0·22	−0·033	−0·041
		Piazzi VI. 292 S.P.	3	18 57 45·43			+0·082	+0·131
		δ Aquilæ.....	6	19 17 5·65				
							+0·168	
		μ Aquilæ	5	19 25 55·54				
							+0·130	
		σ Aquilæ	7	19 30 57·17				
		χ Aquilæ	5	19 34 40·82				
		γ Aquilæ	5	19 38 17·64				
							+0·135	
		β Aquilæ	6	19 47 6·59				
		Aquilæ 204 (Bode)..	7	19 50 47·27				
							+0·145	
		θ Aquilæ.....	6	20 2 43·43				
		α^1 Capricorni.....	5	20 8 29·13				
		α^2 Capricorni.....	6	20 8 52·52				
		λ Ursæ Minoris	4	20 15 12·64			+0·098	
		ν Aquarii	5	21 0 34·36				
		α Equulei.....	7	21 7 29·32				
							+0·145	
		β Aquarii.....	7	21 22 49·00			+0·172	
	W						+0·042	
Aug. 18		κ Ophiuchi.....	5	16 49 41·75		+0·20	−0·004	+0·061
		ε Ursæ Minoris	5	17 1 2·82				
		Groomb. 944 S.P...	2	17 12 52·26			+0·056	
		α Ophiuchi.....	7	17 27 5·97				
		ο Serpentis.....	7	17 32 5·35				
		β Ophiuchi.....	6	17 35 11·22				
							+0·045	
							+0·265	
							+0·070	
							+0·072	
		70 Ophiuchi.....	4	17 56 59·30				
		δ Ursæ Minoris	2	18 20 55·75			+0·085	
	E	δ Ursæ Minoris	2	18 21 4·50	−0·16	−0·22	+0·040	+0·068
		ε Aquilæ.....	7	18 51 56·94				
		Piazzi VI. 292 S.P.	5	18 57 42·48			+0·032	
		22 Aquilæ	7	19 8 13·02				
							+0·105	
		μ Aquilæ	7	19 25 53·20				
							+0·080	
		σ Aquilæ	7	19 30 54·94				
							+0·115	
		γ Aquilæ	5	19 38 15·67				
		α Aquilæ	7	19 42 35·15				
		β Aquilæ	7	19 47 4·25				
		Aquilæ 207 (Bode)..	6	19 52 51·13				
							+0·085	

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow Used for Comparison with Chronometers.
f″	*f″*	*f″*	*s*	*s*	*s*		*s*	*h m*	*s*
x+0·15		−5·27	52·54	35·99	+43·45	G	0·00	18 40	+40·26
	−5·53		15·97	57·30	+41·33				
			1·52	41·85	+40·33				
			51·65	31·98	+40·33				
			53·18	33·54	+40·36				
			37·21	17·39	+40·18				
			13·95	54·47	+40·52				
			2·65	42·93	+40·28				
			42·36	22·46	+40·10				
			39·06	19·32	+40·26				
			24·04	4·16	+40·12				
	−5·44		47·43	28·08	+40·65				
	−5·44		4·31	30·23	+25·92				
			29·37	9·81	+40·44				
			25·31	5·63	+40·32				
x−0·09			44·35	24·87	+40·52				
		−5·45	38·27	20·37	+42·10				
	−5·24		25·27	5·91	+40·64				
	−5·24		5·96	49·03	+43·07				
			2·69	44·93	+42·24				
x+0·15			0·53	42·89	+42·36				
			7·44	49·50	+42·06				
			55·41	37·91	+42·50				
	−5·35		52·26	35·68	+43·42				
x+0·15		−5·15	51·15	35·68	+44·53				
			53·55	36·17	+42·62				
	−5·35		15·05	57·45	+42·40				
			8·55	51·66	+43·11				
			49·35	31·97	+42·62				
			50·99	33·53	+42·54				
			12·00	54·46	+42·46				
			31·40	14·15	+42·75				
			0·35	42·93	+42·58				
			46·29	29·99	+43·70				

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 18	E	θ Aquilæ.....	3	20 2 41·05		−0·22		+0·068
		α^2 Capricorni	6	20 8 50·33				
							+0·049	
							+0·178	
		λ Ursæ Minoris....	4	20 15 10·81				
							+0·108	
							+0·132	
							+0·162	
							+0·145	
		α Equulei.....	3	21 7 26·91				+0·160
							+0·225	
		β Aquarii	7	21 22 46·80				
							+0·187	
Aug. 19								
Aug. 22	W	β Ophiuchi	5	17 35 2·36	− 0·12	+0·20	+0·209	+0·223
		72 Ophiuchi.....	4	17 59 13·49			+0·039	+0·061
		δ Ursæ Minoris	1	18 20 42·68			+0·061	
							+0·056	
Aug. 23		9 Aquilæ.....	3	18 47 57·73			+0·010	+0·038
		ϵ Aquilæ.....	5	18 51 45·99				
		Piazzi VI. 292 S.P.	2	18 57 36·31			+0·028	
		26 Aquilæ.....	4	19 11 28·45				
							0·000	
		36 Aquilæ.....	5	19 21 45·25				
		μ Aquilæ	7	19 25 42·55				
							+0·052	
Aug. 24		ϵ Ursæ Minoris	1	17 1 50·00			+0·056	+0·064
		o Serpentis.....	3	17 32 52·12				
		γ Ophiuchi	7	17 40 16·54				
							+0·062	
		70 Ophiuchi.....	7	17 57 46·45				
							+0·030	
		δ Ursæ Minoris	6	18 21 44·69			+0·070	
		β Lyræ.....	7	18 44 28·90				
		9 Aquilæ	6	18 48 55·64				
							+0·058	
							+0·172	
	E	δ Aquilæ.....	6	19 17 50·46	− 0·11	−0·22		+0·136
							+0·158	
							+0·085	
Aug. 26								
Aug. 27								

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		−5·15	36·74	19·32	+42·58	G	0·00		
x+0·15	−5·50		45·30	28·08	+42·78				
	−5·50		36·40	29·87	+53·47				
			23·00	5·63	+42·63				
			42·27	24·87	+42·60			21 34	+42·74
								14 22	+44·20
x−0·15		−5·42	58·72	49·44	+50·72				
	−5·87		10·04	0·80	+50·76				
x−0·09	−5·87		38·90	34·28	+55·38			18 30	+50·81
x−0·15		−5·45	53·28	46·47	+53·19			13 12	+52·62
	−5·30		42·82	36·12	+53·30				
	−5·30		4·06	58·24	+54·18				
			24·05	17·17	+53·12				
			40·99	34·28	+53·29				
			38·89	31·93	+53·04				
x−0·15	−4·88	−5·47	12·54	4·85	− 7·69				
			47·29	42·81	− 4·48				
	−4·88		12·64	7·72	− 4·92				
			42·55	37·82	− 4·73				
	−5·15		41·43	33·47	− 7·96				
	−5·15		27·11	22·38	− 4·73				
x−0·19			51·19	46·46	− 4·73				
x+0·15		−5·17	46·40	41·79	− 4·61			20 43	− 4·50
x+0·11									
								2 14	+ 0·03
								14 51	+ 1·09

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 29	E	β Ophiuchi	7	17 35 48·25		−0·12	−0·012	+0·031
		δ Ursæ Minoris	5	18 21 34·63			+0·012	
		Piazzi VI. 292 S.P.	4	18 58 23·14			+0·020	
		δ Aquilæ.....	5	19 17 40·31				
							+0·092	
							−0·020	
		γ Aquilæ.....	6	19 38 52·42				
							+0·028	
		α Aquilæ	5	19 43 12·27				
							+0·030	
							+0·082	
		θ Aquilæ	4	20 3 18·30				
		α^2 Capricorni	2	20 9 27·63				
		λ Ursæ Minoris	1	20 15 44·58			+0·081	
	W	λ Ursæ Minoris	1	20 15 22·84	0·00	+0·10	+0·069	+0·040
		ν Aquarii	6	21 1 9·06				
							+0·010	
		α Equulei.....	7	21 8 3·82				
		Piazzi IX. 37 S.P..	3	21 14 42·21			−0·021	
							+0·068	
Aug. 30	E	α Ophiuchi.....	7	17 27 40·99	− 0·04	−0·12	+0·160	+0·161
		δ Ursæ Minoris.....	4	18 21 33·41			+0·080	
		22 Aquilæ	5	19 8 48·29			+0·199	
		γ Aquilæ.....	4	19 38 50·71			+0·218	
		λ Ursæ Minoris	2	20 15 27·20			+0·158	
	W	λ Ursæ Minoris	1	20 15 20·68	− 0·08	+0·10	+0·115	+0·126
		α Equulei.....	6	21 8 1·88				
Aug. 31		δ Ursæ Minoris	2	18 21 31·44	0·00		−0·001	−0·004
		ε Aquilæ	7	18 52 30·15				
		Piazzi VI. 292 S.P.	4	18 58 22·29			−0·060	
		δ Aquilæ.....	7	19 17 36·50				
		36 Aquilæ	6	19 22 29·40				
							−0·055	
		σ Aquilæ	7	19 31 28·20				
		γ Aquilæ	6	19 38 48·85				
							+0·035	
		β Aquilæ.....	7	19 47 37·41				
							−0·010	
		λ Ursæ Minoris	2	20 15 16·51	− 0·08		+0·023	
	E	λ Ursæ Minoris	3	20 15 39·31		−0·12	+0·032	+0·052
		ν Aquarii.....	7	21 1 5·32				
		β Aquarii	5	21 23 20·24			+0·082	
Sep. 2		70 Ophiuchi.....	7	17 57 28·18			+0·056	+0·054
		δ Ursæ Minoris	6	18 21 27·81			+0·036	
		6 Aquilæ	5	18 38 48·41				
		9 Aquilæ	7	18 48 37·28				

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		−5·33	44·22	49·34	+ 5·12	G	0·00		
	−5·49		24·18	31·64	+ 7·46				
x+0·00	−5·49		54·11	59·25	+ 5·14				
			36·18	41·75	+ 5·57				
			48·70	54·38	+ 5·68				
	−5·42		8·45	14·07	+ 5·62				
			13·92	19·26	+ 5·34				
			22·51	28·02	+ 5·51				
			19·06	22·30	+ 3·24				
x−0·06	−5·42		8·60	22·30	+13·70				
			4·28	9·81	+ 5·53				
	−5·35		0·02	5·64	+ 5·62				
x−0·03	−5·35		13·68	19·25	+ 5·57			21 47	+ 5·66
x+0·03	−5·26	−5·28	37·58	44·74	+ 7·16				
	−5·26		24·29	31·30	+ 7·01				
			43·89	51·54	+ 7·65				
x−0·13	−5·52	−5·43	47·02	54·37	+ 7·35				
x−0·17		−5·47	11·03	21·60	+10·57				
x−0·03	−5·52	−5·33	9·86	21·60	+11·74			20 19	+ 7·48
x−0·03			58·14	5·62	+ 7·48				
x−0·03	−5·26	−5·34	24·30	30·95	+ 6·65			14 57	+ 8·83
			26·92	36·01	+ 9·09				
	−5·26		51·66	59·60	+ 7·94				
x−0·05			32·54	41·72	+ 9·18				
			25·12	34·20	+ 9·08				
			24·38	33·42	+ 9·04				
			45·33	54·36	+ 9·03				
	−5·46	−5·57	33·49	42·83	+ 9·34				
x−0·27			7·68	20·91	+13·23				
x+0·03	−5·46	−5·27	12·82	20·91	+ 8·09				
			0·40	9·81	+ 9·41				
			15·65	24·90	+ 9·25				
x+0·03			24·11	37·68	+13·57				
	−5·28		17·10	30·22	+13·12				
			43·90	57·61	+13·71				
			32·70	46·34	+13·64				

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire. h m s	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
					f″	*f″*	*f″*	*f″*
Sep. 2	E	Piazzi VI. 292 S.P.	5	18 58 14·94		−0·12	+0·048	+0·054
		ϑ Aquilæ	5	19 17 31·89				
		36 Aquilæ	7	19 22 24·69				
		μ Aquilæ	5	19 26 21·82				
		α Aquilæ	6	19 43 3·97				
		β Aquilæ	6	19 47 32·96				
		θ Aquilæ	7	20 3 9·53			+0·098	
	W	λ Ursæ Minoris	2	20 15 11·11	−0·02	+0·10	+0·104	+0·132
		θ Capricorni	7	20 57 6·05				
		ν Aquarii	5	21 1 0·94				
		α Equulei	7	21 7 55·49				
		Piazzi IX. 37 S.P.	3	21 14 34·56			+0·139	
Sep. 3		Aquilæ 207 (Bode)	7	19 53 17·71			−0·092	−0·096
		θ Aquilæ	7	20 3 7·75			−0·098	
		α^2 Capricorni	7	20 9 17·08				
		β Capricorni	7	20 12 8·07			−0·068	
		λ Ursæ Minoris	3	20 15 13·52				
		Groomb. 3268	3	20 35 56·25			−0·141	
		75 Draconis	2	20 37 16·12				
	E	ν Aquarii	6	21 0 58·96	−0·02	−0·12	−0·019	−0·086
		α Equulei	6	21 7 53·65			−0·075	
		Piazzi IX. 37 S.P.	5	21 14 29·42			−0·134	
Sep. 4								
Sep. 7								
Sep. 8		Polaris S.P.	1	13 7 59·08	−0·08		+0·008	+0·014
		α Ophiuchi	7	17 28 55·17			−0·012	
		β Ophiuchi	6	17 37 0·18				
		γ Ophiuchi	7	17 41 18·52				
		ν Ophiuchi	7	17 51 41·72			0·000	
		70 Ophiuchi	7	17 58 48·71				
		72 Ophiuchi	4	18 1 10·81				
		ϑ Ursæ Minoris	7	18 22 45·17			+0·058	
		Piazzi VI. 292 S.P.	3	18 59 36·98			−0·009	
		μ Aquilæ	5	19 27 42·48				
		σ Aquilæ	6	19 32 44·19				
		γ Aquilæ	7	19 40 4·64			+0·078	
	W	θ Aquilæ	5	20 4 30·15	−0·02	+0·10	+0·015	+0·030
		α^2 Capricorni	2	20 10 39·68				
		θ Capricorni	4	20 58 26·69			+0·029	

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	−5·23	−5·27	46·12	59·94	+13·82	G	0·00		
			27·82	41·70	+13·88				
			20·28	34·17	+13·89				
			17·99	31·82	+13·83				
			0·23	14·03	+13·80				
			29·07	42·81	+13·74				
			5·22	19·23	+14·01				
x−0·11	−5·47	−5·41	2·92	19·50	+16·58				
			0·88	14·76	+13·88				
			56·14	9·80	+13·66				
			51·69	5·62	+13·93			21 32	+13·94
	−5·47		5·16	19·56	+14·40				
x−0·03		−5·34	14·01	29·86	+15·85				
			3·51	19·22	+15·71				
			12·14	27·99	+15·85				
	−5·63		3·02	18·76	+15·74				
	−5·63		54·18	18·75	+24·57				
x−0·05	−5·39		32·57	49·59	+17·02				
x+0·03		−5·27	53·97	9·80	+15·83				
			49·59	5·62	+16·03				
	−5·39		3·05	19·65	+16·60			23 43	+16·10
								15 6	+17·31*
								19 56	−96·68
x+0·03	−5·23	−5·28	56·50	22·24	−94·26†			13 59	−95·25
	−5·23		51·65	44·58	−67·07			14 12	−67·25
			56·19	49·17	−67·02				
			14·41	7·48	−66·93				
			36·90	29·85	−67·05				
			44·60	37·59	−67·01				
			7·10	0·53	−66·57				
	−5·35		34·00	27·70	−66·30				
	−5·35		8·32	1·04	−67·28				
			38·61	31·75	−66·86				
			40·20	33·33	−66·87				
x+0·01			0·95	54·28	−66·67				
x−0·03		−5·35	25·98	19·18	−66·80				
			34·79	27·94	−66·85				
x−0·07			21·54	14·72	−66·82				

* After this comparison, the clock was put forward 2m.
† After this transit, the clock lost 28s while being wound up.

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire. h m s	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
					f″	*f″*	*f″*	*f″*
Sep. 10	W	Polaris S.P.....	2	13 7 42·95	−0·08	+0·10	+0·060	+0·091
		Arcturus	6	14 9 40·88			+0·105	
					0·00			
Sep. 11	E	Polaris S.P.....	4	13 7 39·04	−0·02	−0·12	+0·118	+0·163
					0·00			
		Arcturus.....	7	14 9 39·11			+0·181	
							+0·190	
							+0·172	
Sep. 12	W	Piazzi VI. 292 S.P.	6	18 59 31·23	+0·01	+0·10	+0·027	+0·069
		26 Aquilæ	7	19 13 20·53			+0·093	
		ϑ Aquilæ	4	19 18 44·66				

The Stationary Chronometers used at Valentia were the following:—

Solar Clock.—The same clock which was used at Kingstown under the name of "House Clock" (the property of Mr. Sheepshanks).

Chronometer 2306.—A chronometer going sidereal time nearly (the property of the Ordnance Department).

Two or three comparisons of these were usually made about the same time; but, for the reasons before mentioned, it has been thought sufficient usually to give here a single comparison.

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
x—0·03	—5·42	—5·35	28·17	22·92	—65·25	G	0·00	13 55	—63·48
x—0·07	—5·42		38·08	34·62	—63·46				
	—5·59	—5·43	28·52	23·23	—65·29			12 47	—61·59
x—0·13	—5·59		36·09	34·61	—61·48				
x—0·03	—5·17	—5·33	0·26	1·79	—58·47			17 5	—59·39
			16·15	16·92	—59·23				
	—5·17		40·77	41·56	—59·21				

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	s″	s″	s″	s″
Aug. 18	E	θ Aquilæ.....	3	20 2 41·05		−0·22		+0·068
		α^2 Capricorni	6	20 8 50·33				
							+0·049	
							+0·178	
		λ Ursæ Minoris....	4	20 15 10·81				
							+0·108	
							+0·132	
							+0·162	
							+0·145	
		α Equulei.....	3	21 7 26·91				+0·160
							+0·225	
		β Aquarii	7	21 22 46·80				
							+0·187	
Aug. 19								
Aug. 22	W	β Ophiuchi	5	17 35 2·36	− 0·12	+0·20	+0·209	+0·223
		72 Ophiuchi.....	4	17 59 13·49			+0·039	+0·061
		∂ Ursæ Minoris	1	18 20 42·68			+0·061	
							+0·056	
Aug. 23		9 Aquilæ.....	3	18 47 57·73			+0·010	+0·038
		ε Aquilæ.....	5	18 51 45·99				
		Piazzi VI. 292 S.P.	2	18 57 36·31			+0·028	
		26 Aquilæ.....	4	19 11 28·45				
							0·000	
		36 Aquilæ.....	5	19 21 45·25				
		μ Aquilæ	7	19 25 42·55				
							+0·052	
Aug. 24		ε Ursæ Minoris	1	17 1 50·00			+0·056	+0·064
		ο Serpentis.....	3	17 32 52·12				
		γ Ophiuchi	7	17 40 16·54				
							+0·062	
		70 Ophiuchi.....	7	17 57 46·45				
							+0·030	
		∂ Ursæ Minoris	6	18 21 44·69			+0·070	
		β Lyræ.....	7	18 44 28·90				
		9 Aquilæ	6	18 48 55·64				
							+0·058	
							+0·172	
	E	∂ Aquilæ.....	6	19 17 50·46	− 0·11	−0·22		+0·136
							+0·158	
							+0·085	
Aug. 26								
Aug. 27								

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		−5·15	36·74	19·32	+42·58	G	0·00		
x+0·15	−5·50		45·30	28·08	+42·78				
	−5·50		36·40	29·87	+53·47				
			23·00	5·63	+42·63				
			42·27	24·87	+42·60			21 34	+42·74
								14 22	+44·20
x−0·15		−5·42	58·72	49·44	+50·72				
	−5·87		10·04	0·80	+50·76				
x−0·09	−5·87		38·90	34·28	+55·38			18 30	+50·81
x−0·15		−5·45	53·28	46·47	+53·19			13 12	+52·62
	−5·30		42·82	36·12	+53·30				
	−5·30		4·06	58·24	+54·18				
			24·05	17·17	+53·12				
			40·99	34·28	+53·29				
			38·89	31·93	+53·04				
x−0·15	−4·88	−5·47	12·54	4·85	− 7·69				
			47·29	42·81	− 4·48				
	−4·88		12·64	7·72	− 4·92				
			42·55	37·82	− 4·73				
	−5·15		41·43	33·47	− 7·96				
	−5·15		27·11	22·38	− 4·73				
x−0·19			51·19	46·46	− 4·73				
x+0·15		−5·17	46·40	41·79	− 4·61			20 43	− 4·50
x+0·11									
								2 14	+ 0·03
								14 51	+ 1·09

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	*f″*	*f″*	*f″*	*f″*
Aug. 29	E	β Ophiuchi	7	17 35 48·25		−0·12	−0·012	+0·031
		δ Ursæ Minoris	5	18 21 34·63			+0·012	
		Piazzi VI. 292 S.P.	4	18 58 23·14			+0·020	
		δ Aquilæ.....	5	19 17 40·31				
							+0·092	
							−0·020	
		γ Aquilæ.....	6	19 38 52·42				
							+0·028	
		α Aquilæ	5	19 43 12·27				
							+0·030	
							+0·082	
		θ Aquilæ	4	20 3 18·30				
		α^2 Capricorni	2	20 9 27·63				
		λ Ursæ Minoris	1	20 15 44·58			+0·081	
	W	λ Ursæ Minoris	1	20 15 22·84	0·00	+0·10	+0·069	+0·040
		ν Aquarii	6	21 1 9·06				
							+0·010	
		α Equulei.....	7	21 8 3·82				
		Piazzi IX. 37 S.P..	3	21 14 42·21			−0·021	
							+0·068	
Aug. 30	E	α Ophiuchi.....	7	17 27 40·99	− 0·04	−0·12	+0·160	+0·161
		δ Ursæ Minoris.....	4	18 21 33·41			+0·080	
		22 Aquilæ	5	19 8 48·29			+0·199	
		γ Aquilæ.....	4	19 38 50·71			+0·218	
		λ Ursæ Minoris	2	20 15 27·20			+0·158	
	W	λ Ursæ Minoris	1	20 15 20·68	− 0·08	+0·10	+0·115	+0·126
		α Equulei.....	6	21 8 1·88				
Aug. 31		δ Ursæ Minoris	2	18 21 31·44	0·00		−0·001	−0·004
		ε Aquilæ	7	18 52 30·15				
		Piazzi VI. 292 S.P.	4	18 58 22·29			−0·060	
		δ Aquilæ.....	7	19 17 36·50				
		36 Aquilæ	6	19 22 29·40				
							−0·055	
		σ Aquilæ	7	19 31 28·20				
		γ Aquilæ	6	19 38 48·85				
							+0·035	
		β Aquilæ.....	7	19 47 37·41				
							−0·010	
		λ Ursæ Minoris	2	20 15 16·51			+0·023	
	E	λ Ursæ Minoris	3	20 15 39·31	− 0·08	−0·12	+0·032	+0·052
		ν Aquarii.....	7	21 1 5·32				
		β Aquarii.....	5	21 23 20·24			+0·082	
Sep. 2		70 Ophiuchi.....	7	17 57 28·18			+0·056	+0·054
		δ Ursæ Minoris	6	18 21 27·81			+0·036	
		6 Aquilæ	5	18 38 48·41				
		9 Aquilæ	7	18 48 37·28				

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
		−5·33	44·22	49·34	+ 5·12	G	0·00		
	−5·49		24·18	31·64	+ 7·46				
x+0·00	−5·49		54·11	59·25	+ 5·14				
			36·18	41·75	+ 5·57				
			48·70	54·38	+ 5·68				
	−5·42		8·45	14·07	+ 5·62				
			13·92	19·26	+ 5·34				
			22·51	28·02	+ 5·51				
			19·06	22·30	+ 3·24				
x−0·06	−5·42		8·60	22·30	+13·70				
			4·28	9·81	+ 5·53				
	−5·35		0·02	5·64	+ 5·62				
x−0·03	−5·35		13·68	19·25	+ 5·57			21 47	+ 5·66
x+0·03	−5·26	−5·28	37·58	44·74	+ 7·16				
	−5·26		24·29	31·30	+ 7·01				
			43·89	51·54	+ 7·65				
x−0·13	−5·52	−5·43	47·02	54·37	+ 7·35				
x−0·17		−5·47	11·03	21·60	+10·57				
x−0·03	−5·52	−5·33	9·86	21·60	+11·74			20 19	+ 7·48
x−0·03			58·14	5·62	+ 7·48				
x−0·03	−5·26	−5·34	24·30	30·95	+ 6·65			14 57	+ 8·83
			26·92	36·01	+ 9·09				
	−5·26		51·66	59·60	+ 7·94				
x−0·05			32·54	41·72	+ 9·18				
			25·12	34·20	+ 9·08				
			24·38	33·42	+ 9·04				
			45·33	54·36	+ 9·03				
	−5·46	−5·57	33·49	42·83	+ 9·34				
x−0·27			7·68	20·91	+13·23				
x+0·03	−5·46	−5·27	12·82	20·91	+ 8·09				
			0·40	9·81	+ 9·41				
			15·65	24·90	+ 9·25				
x+0·03			24·11	37·68	+13·57				
	−5·28		17·10	30·22	+13·12				
			43·90	57·61	+13·71				
			32·70	46·34	+13·64				

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire. h m s	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
					f″	*f″*	*f″*	*f″*
Sep. 2	E	Piazzi VI. 292 S.P.	5	18 58 14·94		−0·12	+0·048	+0·054
		∂ Aquilæ	5	19 17 31·89				
		36 Aquilæ	7	19 22 24·69				
		μ Aquilæ	5	19 26 21·82				
		α Aquilæ	6	19 43 3·97				
		β Aquilæ	6	19 47 32·96				
		θ Aquilæ	7	20 3 9·53			+0·098	
	W	λ Ursæ Minoris	2	20 15 11·11	−0·02	+0·10	+0·104	+0·132
		θ Capricorni	7	20 57 6·05				
		ν Aquarii	5	21 1 0·94				
		α Equulei	7	21 7 55·49				
		Piazzi IX. 37 S.P.	3	21 14 34·56			+0·139	
Sep. 3		Aquilæ 207 (Bode)	7	19 53 17·71			−0·092	−0·096
		θ Aquilæ	7	20 3 7·75			−0·098	
		α^2 Capricorni	7	20 9 17·08				
		β Capricorni	7	20 12 8·07			−0·068	
		λ Ursæ Minoris	3	20 15 13·52				
		Groomb. 3268	3	20 35 56·25			−0·141	
		75 Draconis	2	20 37 16·12				
	E	ν Aquarii	6	21 0 58·96	−0·02	−0·12	−0·019	−0·086
		α Equulei	6	21 7 53·65			−0·075	
		Piazzi IX. 37 S.P.	5	21 14 29·42			−0·134	
Sep. 4								
Sep. 7								
Sep. 8		Polaris S.P.	1	13 7 59·08	−0·08		+0·008	+0·014
		α Ophiuchi	7	17 28 55·17			−0·012	
		β Ophiuchi	6	17 37 0·18				
		γ Ophiuchi	7	17 41 18·52				
		ν Ophiuchi	7	17 51 41·72			0·000	
		70 Ophiuchi	7	17 58 48·71				
		72 Ophiuchi	4	18 1 10·81				
		∂ Ursæ Minoris	7	18 22 45·17			+0·058	
		Piazzi VI. 292 S.P.	3	18 59 36·98			−0·009	
		μ Aquilæ	5	19 27 42·48				
		σ Aquilæ	6	19 32 44·19				
		γ Aquilæ	7	19 40 4·64			+0·078	
	W	θ Aquilæ	5	20 4 30·15	−0·02	+0·10	+0·015	+0·030
		α^2 Capricorni	2	20 10 39·68				
		θ Capricorni	4	20 58 26·69			+0·029	

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f″	*f″*	*f″*	s	s	s		s	h m	s
	−5·23	−5·27	46·12	59·94	+13·82	G	0·00		
			27·82	41·70	+13·88				
			20·28	34·17	+13·89				
			17·99	31·82	+13·83				
			0·23	14·03	+13·80				
			29·07	42·81	+13·74				
			5·22	19·23	+14·01				
x−0·11	−5·47	−5·41	2·92	19·50	+16·58				
			0·88	14·76	+13·88				
			56·14	9·80	+13·66				
			51·69	5·62	+13·93			21 32	+13·94
	−5·47		5·16	19·56	+14·40				
x−0·03		−5·34	14·01	29·86	+15·85				
			3·51	19·22	+15·71				
			12·14	27·99	+15·85				
	−5·63		3·02	18·76	+15·74				
	−5·63		54·18	18·75	+24·57				
x−0·05	−5·39		32·57	49·59	+17·02				
x+0·03		−5·27	53·97	9·80	+15·83				
			49·59	5·62	+16·03				
	−5·39		3·05	19·65	+16·60			23 43	+16·10
								15 6	+17·31*
								19 56	−96·68
x+0·03	−5·23	−5·28	56·50	22·24	−94·26†			13 59	−95·25
	−5·23		51·65	44·58	−67·07			14 12	−67·25
			56·19	49·17	−67·02				
			14·41	7·48	−66·93				
			36·90	29·85	−67·05				
			44·60	37·59	−67·01				
			7·10	0·53	−66·57				
	−5·35		34·00	27·70	−66·30				
	−5·35		8·32	1·04	−67·28				
			38·61	31·75	−66·86				
			40·20	33·33	−66·87				
x+0·01			0·95	54·28	−66·67				
x−0·03		−5·35	25·98	19·18	−66·80				
			34·79	27·94	−66·85				
x−0·07			21·54	14·72	−66·82				

* After this comparison, the clock was put forward 2m.
† After this transit, the clock lost 28s while being wound up.

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TRANSITS OBSERVED AT VALENTIA.

Month and Day, 1844.	Position of Illuminated End.	Star's Name.	Number of Wires observed.	Clock Time of Transit over Middle Wire.	Error of Collimation Found from Observation of Meridian Mark. (Ill. End East.)	Error of Collimation Used.	Error of Level Found.	Error of Level Used.
				h m s	f″	f″	f″	f″
Sep. 10	W	Polaris S.P.....	2	13 7 42·95	−0·08	+0·10	+0·060	+0·091
		Arcturus	6	14 9 40·88			+0·105	
					0·00			
Sep. 11	E	Polaris S.P.....	4	13 7 39·04	−0·02	−0·12	+0·118	+0·163
					0·00			
		Arcturus.....	7	14 9 39·11			+0·181	
							+0·190	
							+0·172	
Sep. 12	W	Piazzi VI. 292 S.P.	6	18 59 31·23	+0·01	+0·10	+0·027	+0·069
		26 Aquilæ	7	19 13 20·53			+0·093	
		♪ Aquilæ	4	19 18 44·66				

The Stationary Chronometers used at Valentia were the following:—

Solar Clock.—The same clock which was used at Kingstown under the name of "House Clock" (the property of Mr. Sheepshanks).

Chronometer 2306.—A chronometer going sidereal time nearly (the property of the Ordnance Department).

Two or three comparisons of these were usually made about the same time; but, for the reasons before mentioned, it has been thought sufficient usually to give here a single comparison.

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TRANSITS OBSERVED AT VALENTIA.

Error of Azimuth Found from Observation of Meridian Mark.	Error of Azimuth Found from Stars.	Error of Azimuth Used.	Seconds of Transit Corrected.	Seconds of Apparent R.A.	Clock Slow.	Observer.	Correction for Personal Equation.	Clock Time of Comparison with Chronometers.	Clock Slow used for Comparison with Chronometers.
f''	*f''*	*f''*	s	s	s		s	h m	s
x—0·03	—5·42	—5·35	28·17	22·92	—65·25	G	0·00	13 55	—63·48
x—0·07	—5·42		38·08	34·62	—63·46				
	—5·59	—5·43	28·52	23·23	—65·29			12 47	—61·59
x—0·13	—5·59		36·09	34·61	—61·48				
x—0·03	—5·17	—5·33	0·26	1·79	—58·47			17 5	—59·39
	—5·17		16·15	16·92	—59·23				
			40·77	41·56	—59·21				

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COMPARISONS OF STATIONARY CHRONOMETERS AT VALENTIA.

Approximate Solar Time, 1844.	Time of Transit Clock at Comparison.	Corresponding Time of Solar Clock.	Solar Clock Slow.	Time of Solar Clock at Comparison.	Corresponding Time of 2306.	2306 Slow.
d h	h m s	h m s	m s	h m s	h m s	m s
Aug. 7 8	17 16 32	8 15 15	− 4 11·09	....	....	....
8 2	11 6 49	2 2 45	− 4 17·60	2 8 50	11 12 55·0	+0 19·71
10 9	18 49 3	9 36 15	− 4 35·34	9 40 22	18 53 11·5	+0 24·72
11 5	14 26 60	5 11 8	− 4 42·57	5 13 33	14 29 26·0	+0 26·69
15 2	12 24 12	2 53 40	− 5 17·71	2 51 48	12 22 20·5	+0 34·91
17 9	18 40 49	9 1 50	− 5 39·69	9 5 15	18 44 15·5	+0 39·30
18 11	21 33 35	11 50 25	− 5 50·43	12 2 22	21 45 35·0	+0 41·62
19 4	14 22 42	4 36 55	− 5 57·29	4 38 42	14 24 30·5	+0 42·99
22 8	18 29 46	8 32 10	− 6 29·89	8 43 22	18 41 2·0	+0 48·58
23 3	13 11 50	3 11 20	− 6 37·92	3 8 30	13 9 1·5	+0 50·67
24 10	20 42 43	10 36 20	− 6 51·66	10 29 36	20 35 0·0	+0 53·44
26 16	2 14 30	15 59 49	− 7 15·30	15 57 18	2 11 0·5	+0 58·15
27 4	14 50 50	4 34 12	− 7 21·15	4 30 45	14 46 24·5	+0 59·07
29 11	21 46 58	11 21 50	− 7 46·59	11 26 24	21 50 35·5	+1 2·87
30 9	20 18 57	9 50 20	− 7 57·25	10 30 44	20 58 30·5	+1 4·30
31 4	14 57 20	4 25 50	− 8 6·13	4 15 28	14 46 0·0	+1 5·21
Sep. 2 10	21 32 30	10 52 35	− 8 32·59	10 55 20	21 34 20·0	+1 9·36
3 12	23 43 42	12 59 45	− 8 45·83	13 5 27	23 48 30·0	+1 10·99
4 4	15 5 44	4 19 25	− 8 53·67	4 20 35	15 5 59·5	+1 12·01
7 8	19 56 0	8 55 52	− 9 33·63	9 0 16	19 57 30·5	+1 17·49
8 2	13 59 55	2 57 0	− 9 42·78	2 49 20	13 49 19·5	+1 19·04
8 3	14 12 29	3 10 0	− 9 42·91	....	....	....
10 2	13 55 0	2 45 11	−10 8·10	2 48 28	13 55 50·5	+1 23·52
11 1	12 47 50	1 34 30	−10 20·12	1 30 30	12 41 22·0	+1 25·80
12 5	17 5 41	5 48 0	−10 35·08	5 45 32	17 0 45·0	+1 28·23

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The "chronometer slow" for the times of comparison with travelling chronometers has been interpolated by simple proportion of times between the "chronometer slow" for the times of groups of transits, and then the following corrections have been applied for change of chronometer rates:—

		d	h		s
Solar Clock	August...	11	3	.....	+ 0·29
		19	3	.....	+ 0·17
		23	2	.....	+ 0·01
		26	15	.....	+ 0·52
		27	3	.....	+ 0·52
		31	5	.....	+ 0·01
	September	3	14	.....	+ 0·03
		4	3	.....	+ 0·16
		8	3	.....	+ 0·03
		12	4	.....	+ 0·01
Chronometer 2306..	August	26	15	.....	+ 0·18
		27	3	.....	+ 0·19
	September	4	3	.....	− 0·09

By means of these corrected interpolations, as at Kingstown, the following table of corrections to the Transit Clock Errors is formed; applying to all the times of comparison of travelling chronometers except two (August 7, 4^h and August 15, 2^h), which were sufficiently near to groups of transits:—

CORRECTIONS TO THE ERROR OF TRANSIT CLOCK AT VALENTIA, AS SHEWN BY THE DIFFERENT STATIONARY CHRONOMETERS.

	August 11^d 3^h	August 19^d 3^h	August 23^d 2^h	August 26^d 15^h	August 27^d 3^h	August 31^d 3^h	Sep. 3^d 14^h	Sep. 4^d 3^h	Sep. 8^d 3^h	Sep. 12^d 4^h
	s	s	s	s	s	s	s	s	s	s
Transit Clock...	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·00
Solar Clock....	+0·20	−0·17	+0·03	−0·18	−0·08	−0·08	+0·04	+0·06	−0·07	0·00
Sidereal Chronometer 2306	−0·21	−0·09	−0·07	−0·34	−0·27	0·00	+0·06	+0·05	0·00	−0·02
Mean.....	0·00	−0·09	−0·01	−0·17	−0·12	−0·03	+0·03	+0·04	−0·02	−0·01

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VIII.—*List of Travelling Chronometers; Method of using Travelling Chronometers, of combining Results, and of deducing probable Errors.*

The stock of pocket-chronometers belonging to the Government, and in my charge at the Royal Observatory, being insufficient for the determination of longitude with the accuracy which I desired, I had recourse to the kindness of Mr. Sheepshanks, and of several eminent chronometer-makers, for the loan of a sufficient number to make up my full complement of thirty. In every instance most obliging attention was given to my request; and I think it my duty publicly to acknowledge my obligations to these gentlemen for the prompt supply and gratuitous loan of these valuable instruments. To Mr. Sheepshanks in particular I am indebted for the use of ten chronometers of somewhat larger size than the rest, and of generally superior construction. A list will be subjoined, after a few remarks explanatory of the reasons for separating them into classes.

In the greater part of the chronometers, 150 beats were made in one minute; or the seconds' hand advanced at each beat four-tenths of a second, or in five beats advanced two seconds. Therefore, if the circle were properly divided, and if we found one second to which the hand pointed exactly at any beat, it would point exactly to every alternate second, counted from that first second. It was soon seen, however, that the circles were very inaccurately divided; and it became necessary, therefore, to make conspicuous marks on the circles (by small lines in Indian ink) at every alternate second, so as in some parts to correct the divisions of the circle, and in all to indicate the seconds at which the coincidence of the hand with the second was assumed to take place. In some of these chronometers the coincidence took place at every even second, and in others at every odd second.

A few of the chronometers made 160 beats in a minute; they, therefore, made eight beats in three seconds, or four beats in one and a half second. The places of the coincidences of the hand with the division were marked on these for every one and a half second, assuming always that the coincidence took place at 0ˢ upon the divided circle.

The chronometers were all adjusted to go to mean solar time very nearly. The transit clocks (or, in some instances, the half-second chronometers) with

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which they were to be compared, went to sidereal time very nearly. Thus the comparison of the two was made with very great accuracy by coincidence of beats. In listening for a short time to the mingled beats of the solar and sidereal timekeepers, it is easy to fix upon one recurring series of beats following a certain order, in which series there are two beats (one of the solar and one of the sidereal time-keeper) which approach more and more nearly to coincidence, advancing towards it by, perhaps, $\frac{1}{100}$ of a second at each recurrence, by reason of the gain of the sidereal upon the solar time-keeper. The exact time of coincidence can be seized by a practised ear with great accuracy. This time being fixed on, the readings of the two time-keepers at the coincidence are to be entered in the memorandum-book. Some observers will, perhaps, take both readings at once; others will prefer to enter in the book the reading of the quicker-beating chronometer, and to count mentally the beats of the other till an opportunity presents itself of reading its face at leisure. Then the observer is free, either roughly to make another comparison as a check on the whole number of seconds, minutes, and hours, or to prepare himself for the next coincidence of beats.

In any case, to avoid the confusion into which an observer, fatigued with the comparison of so many chronometers, might easily fall, it was desirable that he should be prepared to decide without much thought upon the nature of the reading at which a coincidence was next to be expected. For this purpose (at Mr. Sheepshanks' suggestion) the chronometers were arranged in their cases in the following order. First, the 150-beat chronometers which indicated whole seconds at every even second (these extend from *A* to *U* in the following list). Secondly, the 150-beat chronometers which indicated whole seconds at every odd second (these extend from *W* to *b*). Thirdly, the 160-beat chronometers. The letters *V* and *c* were passed over, in order to call the observer's attention to this separation of classes.

The chronometer *L* failed after several journeys, and *K** was substituted for it.

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LIST OF TRAVELLING CHRONOMETERS.

No. of Travelling Case.	Letter of Reference to Chronometer.	Maker's Name and Maker's Number or Letter.	How obtained.
I.	*A*	R. Molyneux..... *A*	Lent by Mr. Sheepshanks.
	B	Do. ..... *B*	Do.
	C	Do. ..... *C*	Do.
	D	Do. ..... *D*	Do.
	E	Do. ..... *E*	Do.
	F	Do. ..... *F*	Do.
	G	Do. ..... *H*	Do.
	H	Do. ..... *K*	Do.
	I	Do. 1	Lent by Mr. R. Molyneux.
	J	Do. 3	Do.
	K	Do. 4	Do.
	*K**	Dent.....6513	Lent by Mr. Dent.
	L	Parkinson and Frodsham, 251	Lent by Messrs. Parkinson and Frodsham.
	M	Do. 699	The property of the Government.
	N	Do. 750	Do.
	O	Do. 2312	Lent by Messrs. Parkinson and Frodsham.
II.	*P*	Do. 2709	The property of the Government.
	Q	Arnold.....2131	Lent by Mr. Dent.
	R	Do.....6063	Lent by Mr. C. Frodsham.
	S	Dent.....5876	Lent by Mr. Dent.
	T	Do.....6514	Do.
	U	R. Molyneux..... *G*	Lent by Mr. Sheepshanks.
	W	Do. ..... *I*	Do.
	X	Do. 5	Lent by Mr. R. Molyneux.
	Y	Parkinson and Frodsham, 1230	The property of the Government.
	Z	Do. 2310	Do.
	a	Arnold.....5416	Lent by Mr. C. Frodsham.
	b	M'Cabe..... 194	The property of the Government.
	d	Arnold..... 2139	Lent by Mr. Dent.
	e	Do. 2164	The property of the Government.
	f	Do. 2181	Lent by Mr. Dent.

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The chronometers when travelling backwards and forwards between two stations were compared sometimes once (nearly at the middle of the time of stopping at the station), sometimes twice (immediately after arrival, and immediately before departure). At these comparisons, sometimes entire reliance was placed on a single coincidence of beats accurately observed, with a rough observation for check; sometimes several coincidences were accurately observed. The selections among these different arrangements will be described in the account of the observations for each separate arc.

In describing the method of calculating these observations, I must remark that a change of system was made in the course of the calculations. The first system is that which has usually been adopted; the second is that which, upon mature consideration, I have satisfied myself ought to be adopted in every case. The whole had been computed on the first system before the propriety of the second occurred to me. Advantage was then taken of the calculated results of the first system; and thus, although a form was adopted differing from that which I should have used if the second system had presented itself to me at an earlier stage, very little labour was lost.

In the first system, the times of the transit-clock or stationary chronometer at comparison were corrected so as to exhibit the true sidereal time at every comparison at each station. Then, adopting one extremity of each arc of longitude as the fundamental point, and considering the other extremity as the derived point; the sidereal time at the comparison at the fundamental point was converted into mean solar time by exactly the same process as if that fundamental point were Greenwich. In all cases, therefore, where the fundamental point was not Greenwich, there was a constant error in the resulting mean solar time; but this error disappeared when the reverse process of converting mean solar time into sidereal time was conducted in the same manner as if the place were Greenwich. The mean solar time being thus found at comparison with the solar chronometer, the "chronometer slow" for the solar chronometer was obtained, subject, however, to a constant error. By comparing successive "chronometer slow" at the fundamental point, the chronometer's rate was found; and by applying a proportional part of this, the "chronometer slow" at the time of comparison at the derived point was found, subject to the same error as before. Applying this "chronometer slow" to the chronometer time at comparison, the mean solar time was found, subject to the same error (in regard to time at the fundamental point) as

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before; and then converting this into sidereal time as for Greenwich, the sidereal time related to the fundamental point was found for the time of comparison at the derived point, free from error. Comparing this with the sidereal time related to the derived point, the difference of longitude was found.

In the instances where the first comparison at the derived station preceded all the comparisons at the fundamental station, the first chronometer rate at the fundamental station was carried backwards. And when the last comparison at the derived station followed all at the fundamental station, the last chronometer rate at the fundamental station was carried forwards.

These computations constituted the first system.

Now it is evident here that the chronometer rates thus carried forwards or backwards were adopted without sufficient authority. It is evident also that no use is made of the comparisons at the derived station for giving the chronometer rates; although these comparisons are in all respects as available for this purpose as the comparisons at the fundamental station.

The proper method of using the comparisons at the derived station would have been to convert all the sidereal times referred to the derived station into mean solar times (subject to a constant error, differing from that previously mentioned), and to compare the chronometer times with these; the rates deduced from these comparisons would have been free from error.

But, the calculations on the first system having been finished, the following was a much easier method of deducing the rates from the comparisons at the derived station. Let L be the true longitude of the derived station, considered positive when it is west of the fundamental point; l the longitude resulting from any one comparison; *c.s.* the adopted "chronometer slow," by the use of which the longitude l was found; *C. S.* the true "chronometer slow," by the use of which the true longitude, L, would have been found. Then, as increase of the "chronometer slow," which is applied to a given chronometer time, does increase the nominal time referred to the fundamental point, and thus does increase the apparent difference of longitude, we shall have,

$$C.S. - c.s. = L - l,$$

which is subject to no other error than this, that one side is in solar time, and the other in sidereal time, whose difference (when the whole quantity does not exceed one or two seconds) is insensible. From this we find,

$$C.S. = c.s. - l + L;$$

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and as, for the purpose of finding rates, the omission of a constant is unimportant, we may use,

$$C.S. = c.s. - \text{seconds of } l.$$

By means of the "chronometer slow" determined by this rule for each of the comparisons at the derived station, the rates from the comparisons at the derived station were obtained with accuracy.

Suppose now, to fix our ideas, that only one comparison was made at each station between the arrival and the departure of the chronometers; and suppose the intervals of time from one comparison to another were equal throughout. And let the rates, determined from the successive comparisons at that station (it matters not whether the fundamental or the derived), where the first comparison was made, be called a_1, a_3, a_5, &c., and let the rates, determined from the successive comparisons at the other station be called b_2, b_4, b_6, &c. Then it is evident that the rate b_2 appears to extend over a time which is partly subject to the rate a_1, and partly to the rate a_3; and so for every other rate. We have no reason, therefore, to fix upon either a_1 or b_2 or a_3, as applying either to the whole or to a portion of this time. And the only supposition, which we can with propriety make, is, that the rates may be different in every successive portion of time included between two proximate comparisons. Calling these x_1, x_2, x_3, &c., the relation in succession of the periods to which all the rates apply may be represented by the following scheme:—

Apparent Rates from Comparisons at First Station.	Apparent Rates from Comparisons at Second Station.	True Rates.
		x_1
a_1	b_2	x_2
		x_3
a_3	b_4	x_4
		x_5
a_5	b_6	x_6
		x_7
a_7	b_8	x_8
		x_9
a_9	b_{10}	x_{10}
		x_{11}
a_{11}	&c.	x_{12}
&c.		&c.

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And the question now is, what principle shall be adopted for the determination of x_1, x_2, &c.?

First, supposing the intervals of comparison equal, we have these necessary equations:—

$$x_1 + x_2 = 2a_1;\ x_2 + x_3 = 2b_2;\ x_3 + x_4 = 2a_3,\ \&c.;$$

so that, having adopted any one rate, the other rates will be immediately deduced from it.

Secondly, the condition which I have adopted is this: that the quantity which is analogous to the error of observation in ordinary applications of the theory of probabilities, is, in this case, the change of chronometer's rate between one interval and the next; and, therefore, that the sum of the squares of these changes ought to be made minimum. Or, in other words, that

$$(x_1 - x_2)^2 + (x_2 - x_3)^2 + (x_3 - x_4)^2 + \&c.$$

ought to be made minimum. It will be more convenient to express it thus:—that

$$(x_2 - x_1)^2 + (x_2 - x_3)^2 + (x_4 - x_3)^2 + (x_4 - x_5)^2 + \&c.$$

shall be minimum.

Now, under the assumed equality of intervals,

$$\begin{aligned}
x_2 &= 2a_1 - x_1 \\
x_3 &= 2b_2 - x_2 = 2b_2 - 2a_1 + x_1 \\
x_4 &= 2a_3 - x_3 = 2a_3 - 2b_2 + 2a_1 - x_1 \\
x_5 &= 2b_4 - x_4 = 2b_4 - 2a_3 + 2b_2 - 2a_1 + x_1, \\
&\&c. = \&c. \\
x_2 - x_1 &= -2x_1 + 2a_1 \\
x_2 - x_3 &= -2x_1 + 4a_1 - 2b_2 \\
x_4 - x_3 &= -2x_1 + 4a_1 - 4b_2 + 2a_3 \\
x_4 - x_5 &= -2x_1 + 4a_1 - 4b_2 + 4a_3 - 2b_4, \\
&\&c. = \&c.
\end{aligned}$$

and making the sum of squares a minimum, and supposing that there are n rates, or $\overline{n-1}$ changes of rate,

$$0 = -(n-1)\,x_1 + (2n-3)\,a_1 - (2n-5)\,b_2 + (2n-7)\,a_3 - \&c.,$$

from which x_1 is determined. Then from the equations above, x_2, x_3, &c., are found.

Theoretically there is no necessity for finding the rates x_2, x_3, &c., inasmuch as, from the nature of the process for determining the rates by comparisons at the derived station, the use of any of these rates will give the same longitude for

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the derived station. But it is prudent to find and apply some of these rates (in these computations I have used all) in order to have the power of taking the mean of several results, each of which is affected with the accumulation of small errors. And it is necessary to find the rates, for the estimation of the probable error of the result, in the following method.

The change of rate between one interval and the next being considered as analagous to an error of observation, and the sum of squares of these errors being made minimum, the probable change of rate will be found by the same rule as that given by the theory of probabilities for the probable error of an observation; and it will, therefore, be

$$\pm 0{\cdot}6745 \times \sqrt{\frac{\text{minimum sum of squares of differences of rate}}{n-1}}.$$

Now the analogy between the change of rate and the error of an observation is rigorously close to this point, that a change in the value of the element to be determined (which in one case is the first rate x_1, and in the other case is the result of the observations,) affects in one case all the residual changes of rate by the same $\pm$ quantity, and in the other case all the residual errors of observation by the same $\pm$ quantity. But there is this difference, that in one case an alteration, z, in the rate x_1, affects every residual change of rate by $\pm 2z$, whereas an alteration, z, in the presumed result of observations, affects every residual error of observation by $\pm z$. Hence, applying the same rule to the probable error of x_1 as to the probable error of a result of $n-1$ observations, we must take only half the quantity so computed. Thus we get for the probable errror of x_1

$$\frac{\pm 0{\cdot}3372}{n-1} \times \sqrt{\text{minimum sum of squares of differences of rate,}}$$

and the probable error of the determined longitude will be

$$\frac{\pm 0{\cdot}3372}{n-1} \times \sqrt{\text{minimum sum of squares of diff. of rate}} \times \frac{\text{time through which one rate is used}}{24^h}.$$

The number which was used for the weight of the result derived from each chronometer was

$$\frac{1000}{\text{minimum sum of squares of differences of rates,}}$$

in which expression the numerator is arbitrary; but the denominator is that indicated by the theory of probabilities, as proper to be used in the combination of the results of different chronometers, on the assumptions mentioned

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above. Therefore, using the letter W for this quantity, the probable error of the determined longitude will be,

$$\frac{\pm 0{\cdot}3372}{n-1} \times \sqrt{\frac{1000}{W}} \times \frac{\text{time through which one rate is used}}{24^h},$$

which, for a moment, we will call $\frac{E}{\sqrt{W}}$. All this applies to the probable error of longitude as determined by only one chronometer.

Suppose now that we combine the results L_A, L_B, L_C, &c., for the longitude given by the different chronometers A, B, C, &c.; and suppose that we give to the respective chronometers the weights W_A, W_B, W_C, &c., as found by the formula above. This means that we take for our final longitude,

$$L = \frac{W_A \cdot L_A + W_B \cdot L_B + W_C \cdot L_C + \&c.}{W_A + W_B + W_C + \&c.}$$

$$\text{Or, } L = \frac{W_A}{W_A + W_B + W_C + \&c.} L_A + \frac{W_B}{W_A + W_B + W_C + \&c.} L_B + \frac{W_C}{W_A + W_B + W_C + \&c.} L_C + \&c.$$

Remarking that this expression consists of the sum of a number of terms, each of which is subject to an error, whose probable amount is defined above, and therefore that, by the theory of probabilities, the probable error of the sum is the square root of the sum of the squares of the probable errors of the different terms: and, remarking that the probable error of L_A, from the formula above, is $\frac{E}{\sqrt{W_A}}$, and, therefore, that the probable error of

$$\frac{W_A}{W_A + W_B + W_C + \&c.} L_A \text{ is } \frac{E}{W_A + W_B + W_C + \&c.} \sqrt{W_A},$$

we find for the probable error of L,

$$\frac{E}{W_A + W_B + W_C + \&c.} \sqrt{(W_A + W_B + W_C + \&c.)};$$

$$\text{or, } \frac{E}{\sqrt{(W_A + W_B + W_C + \&c.)}};$$

or, restoring the value of E,

$$\frac{\pm 0{\cdot}3372}{n-1} \times \sqrt{\frac{1000}{\text{Sum of weights}}} \times \frac{\text{time through which one rate is used}}{24^h}.$$

Some modifications in this method are necessary when the intervals between the comparisons are not equal; and attention is sometimes necessary to this consideration, that there is strong reason for believing that the chronometer's rate is not the same when it is journeying as when it is at rest. These matters, however, will be noticed in the accounts of the determinations for the special arcs to which they apply.

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IX.—*Comparisons and Calculations for the Longitude of Liverpool, as determined with reference to Greenwich.*

The comparisons at Greenwich and at Liverpool were made as immediately as possible after arrival and before departure of the chronometers. Thus between one comparison at Greenwich before departure of the chronometers, and the next comparison after their return, there were three different periods of time to be considered, namely, the time occupied by the journey to Liverpool, the time of the chronometer's rest at Liverpool between the two comparisons there, and the time occupied by the journey back to Greenwich. As the two comparisons at Greenwich give the whole time and whole chronometer-loss during the three periods, and as the two intervening comparisons at Liverpool give the time and chronometer-loss during the stationary period, on subtracting the latter from the former we obtain the whole time and chronometer-loss, and consequently the apparent rate, during the two travelling periods. A process exactly similar applies with regard to the three periods intervening between the time of the chronometers' departure from Liverpool and that of their return to Liverpool. The apparent travelling rates, a_1, b_2, &c., are thus obtained, and the intervals through which they apply, being nearly equal, are supposed to be exactly equal; and the rates x_1, x_2, &c., are determined by the process of Section VIII. Then each of the odd rates, x_1, x_3, &c., is used to determine the longitude; and, as there are trifling discordances in the results, arising from the combination of the two circumstances that the travelling intervals are not precisely equal, and that the rates undergo a small change, the mean of the results is adopted. This is the process used with each separate chronometer.

For the combination of all the chronometers, the sum of the squares of the differences of successive rates, x_1, x_2, &c., was taken for each chronometer; but this was not used solely to determine the weights. I thought it best to take into account the stationary rates also of the chronometers, determined from the two comparisons at each place made between the arrival and the departure of the chronometers. The differences of these stationary rates being taken, and the sum of the squares of the differences being formed, this sum was added to $\frac{1}{3}$ of the sum of the squares of the differences of the travelling rates:

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and the quotient of 1000 by the compound sum was used for the weight or W.

As this process implied that the importance attached to a square of difference of a stationary rate was only $\frac{3}{4}$ of that attached to a square of difference of a travelling rate, and as there were 6 differences of travelling rates and 5 differences of stationary rates, they were treated thus.

The number of differences of travelling rates is $6 + \frac{3}{4} \times 5 = \frac{39}{4}$. The quantity used for $\frac{1000}{W}$ is $\frac{3}{4} \times (6 + \frac{3}{4} \times 5)$ squares of differences $= \frac{3}{4} \cdot \frac{39}{4}$ squares of differences. Therefore, the quantity which ought to have been used for the sum of squares of differences is $\frac{3}{4} \cdot \frac{1000}{W}$. As this corresponds to $\frac{39}{4}$ differences, and as we want the quantity corresponding to six differences, we must take $\frac{24}{39} \cdot \frac{3}{4} \cdot \frac{1000}{W}$, or $\frac{6000}{13} \cdot \frac{1}{W}$. After this, the formula of Section VIII. applies, with no other alteration than substituting $\frac{6000}{13}$ for 1000. As the time of a journey, or rather the interval of comparisons, was nearly 13^h, the last fraction of the formula becomes $\frac{13}{24}$. Thus we have for the probable error of longitude,

$$\frac{0{\cdot}3372}{6} \times \sqrt{\frac{6000}{13 \times \text{sum of weights}}} \times \frac{13}{24}.$$

This will be expressed in seconds of time, because the differences of rate from which the weights are found are so expressed.

The following tables contain every essential part of the process.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER A.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 6 4·4	+ 1 27·83	5 55 25	11 60·17		
									+0·49	+0·38
21 7	20 8 15	8 4 30·4	+ 1 27·76							
				−0·12						
22 19	7 30 59	19 21 28·8	+ 1 27·59							
				+0·59					+0·49	+0·60
23 7					6 59 16·0	+ 1 27·89	18 58 37	11 59·88		
									+0·63	
23 18					18 8 22·8	+ 1 28·17	6 9 34	11 59·87		
				+0·59					+0·64	+0·58
24 8	19 57 12	7 41 44·8	+ 1 28·50							
				+1·10						
24 19	7 45 57	19 28 34·0	+ 1 29·06							
				+0·68					+0·64	+0·70
25 8					8 11 47·6	+ 1 29·49	20 19 15	11 59·94		
									+1·17	
25 18					18 19 4·4	+ 1 29·85	6 28 12	11 59·81		
				+0·68					+0·59	+0·66
26 8	20 25 31	8 2 8·4	+ 1 30·30							
				+1·11						
26 19	7 16 36	18 51 26·8	+ 1 30·80							
				+0·66					+0·59	+0·52
27 9					8 55 30·8	+ 1 31·35	21 11 0	11 60·12		
									+1·71	
27 18					18 13 15·6	+ 1 31·70	6 30 17	11 59·81		
				+0·66						+0·80
28 8	20 21 24	7 49 10·8	+ 1 32·22							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·87 West.

CHRONOMETER B.

Sep.										
20 18					17 56 33·6	+13 22·71	5 57 49	11 60·64		
									+5·81	+5·62
21 7	20 9 52	7 54 9·6	+13 25·30							
				+4·40						
22 19	7 32 19	19 10 44·4	+13 31·77							
				+5·82					+5·81	+6·00
23 7					6 50 2·8	+13 34·31	19 1 31	11 59·57		
									+4·44	
23 18					17 59 20·8	+13 36·83	6 12 41	11 60·04		
				+5·82					+5·40	+5·64
24 8	19 58 24	7 30 45·2	+13 39·90							
				+4·78						
24 19	7 47 10	19 17 33·6	+13 42·27							
				+5·52					+5·40	+5·16
25 8					8 1 20·8	+13 45·05	20 21 4	11 59·99		
									+4·84	
25 18					18 8 56·0	+13 47·27	6 30 21	11 60·18		
				+5·52					+5·97	+5·88
26 8	20 26 20	7 50 37·2	+13 50·37							
				+4·07						
26 19	7 17 44	18 40 13·2	+13 52·21							
				+5·94					+5·97	+6·06
27 9					8 45 24·8	+13 55·53	21 13 19	11 59·67		
									+5·15	
27 18					18 4 42·0	+13 57·72	6 34 10	11 59·87		
				+5·94						+5·82
28 8	20 22 29	7 37 46·8	+14 1·04							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·87.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer C.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 4 30·0	+ 8 5·45	6 0 30	11 59·22		
									+2 58	+1·97
21 7	20 10 48	8 0 23·2	+ 8 7·55							
				+3·55						
22 19	7 33 37	19 17 21·2	+ 8 12·76							
				+2·95					+2·58	+3·19
23 7					6 58 50·8	+ 8 14·22	19 4 59	11 60·05		
									+3·24	
23 18					18 6 39·6	+ 8 15·65	6 14 39	11 59·98		
				+2·95					+2·49	+2·71
24 8	19 59 26	7 37 9·6	+ 8 17·34							
				+4·37						
24 19	7 49 24	19 25 10·0	+ 8 19·51							
				+2·90					+2·49	+2·27
25 8					8 8 36·0	+ 8 21·21	20 22 55	11 60·66		
									+4·10	
25 18					18 16 50·4	+ 8 22·56	6 32 51	11 60·29		
				+2·90					+3·18	+3·53
26 8	20 27 15	7 56 58·0	+ 8 24·42							
				+4·29						
26 19	7 19 12	18 47 6·8	+ 8 26·36							
				+2·48					+3·18	+2·83
27 9					8 53 0·4	+ 8 28·06	21 15 27	11 60·16		
									+4·24	
27 18					18 15 38·4	+ 8 29·20	6 39 39	11 59·64		
				+2·48						+2·13
28 8	20 23 31	7 44 18·8	+ 8 30·87							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·12.

Chronometer D.

Sep.										
20 18					18 8 57·2	+ 6 30·76	6 3 21	11 61·20		
									+6·10	+6·78
21 7	20 12 0	8 3 9·6	+ 6 32·94							
				+3·72						
22 19	7 34 36	19 19 54·4	+ 6 38·40							
				+5·10					+6·10	+5·42
23 7					7 1 53·2	+ 6 40·81	19 6 29	11 59·28		
									+4·89	
23 18					18 11 4·0	+ 6 43·21	6 17 32	11 59·41		
				+5·10					+5·13	+4·78
24 8	20 1 15	7 40 29·6	+ 6 46·03							
				+5·48						
24 19	7 50 25	19 27 41·6	+ 6 48·74							
				+5·53					+5·13	+5·48
25 8					8 13 52·8	+ 6 51·27	20 26 44	11 59·14		
									+3·00	
25 18					18 26 6·0	+ 6 53·31	6 40 39	11 59·91		
				+5·53					+5·56	+5·58
26 8	20 28 18	7 59 29·2	+ 6 56·05							
				+4·21						
26 19	7 20 33	18 49 56·0	+ 6 57·95							
				+5·46					+5·56	+5·54
27 9					8 56 41·2	+ 7 0·78	21 17 42	11 59·05		
									+3·09	
27 18					18 19 37·6	+ 7 2·68	6 42 12	11 59·74		
				+5·46						+5·38
28 8	20 24 57	7 47 10·0	+ 7 5·44							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·48.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER E.

Approximate Solar Time, 1844.	Comparisons at Greenwich: Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Comparisons at Liverpool: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 20 4·8	+ 0 4·70	6 8 4	11 60·52		
									+1·04	+1·26
21 7	20 13 18	8 10 55·6	+ 0 4·74							
				+0·07						
22 19	7 35 39	19 27 30·8	+ 0 4·84							
				+0·82					+1·04	+0·82
23 7					7 10 30·0	+ 0 5·28	19 8 30	11 59·89		
									+1·08	
23 18					18 19 33·6	+ 0 5·71	6 19 24	11 59·82		
				+0·82					+0·40	+0·82
24 8	20 2 45	7 48 39·2	+ 0 6·20							
				+0·55						
24 19	7 51 57	19 35 55·6	+ 0 6·49							
				+0·12					+0·40	−0·02
25 8					8 22 38·0	+ 0 6·48	20 28 44	11 59·87		
									−0·38	
25 18					18 35 1·6	+ 0 6·47	6 42 48	11 60·02		
				+0·12					+0·47	+0·26
26 8	20 29 29	8. 7 29·6	+ 0 6·46							
				+1·08						
26 19	7 21 45	18 57 58·8	+ 0 6·95							
				+0·10					+0·47	+0·68
27 9					9 6 14·0	+ 0 6·92	21 20 21	11 59·43		
									−0·51	
27 18					18 30 29·6	+ 0 6·90	6 46 9	11 59·61		
				+0·10						−0·48
28 8	20 25 59	7 55 10·4	+ 0 6·87							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·85.

CHRONOMETER F.

Sep.										
20 18					18 20 16·0	+ 2 46·06	6 10 56	11 61·55		
									+2·82	+2·80
21 7	20 14 23	8 9 19·2	+ 2 45·95							
				−0·20						
22 19	7 36 46	19 25 56·8	+ 2 45·66							
				+2·24					+2·82	+2·84
23 7					7 10 0·8	+ 2 46·49	19 10 43	11 59·26		
									+0·50	
23 18					18 19 29·6	+ 2 47·30	6 22 2	11 59·84		
				+2·24					+1·49	+1·64
24 8	20 3 40	7 46 52·0	+ 2 48·24							
				+0·86						
24 19	7 53 13	19 34 29·2	+ 2 48·68							
				+1·39					+1·49	+1·34
25 8					8 22 45·6	+ 2 49·09	20 31 35	11 59·56		
									−0·85	
25 18					8 35 12·4	+ 2 49·42	6 45 42	11 60·25		
				+1·39					+1·17	+1·44
26 8	20 30 51	8 6 8·0	+ 2 49·84							
				+1·51						
26 19	7 23 8	18 56 38·0	+ 2 50·52							
				+1·07					+1·17	+0·90
27 9					9 5 18·0	+ 2 50·89	21 22 9	11 59·68		
									−0·66	
27 18					18 34 40·8	+ 2 51·14	6 53 5	11 60·19		
				+1·07						+1·24
28 8	20 27 7	7 53 33·6	+ 2 51·49							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·85.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer C.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 4 30·0	+ 8 5·45	6 0 30	11 59·22		
21 7	20 10 48	8 0 23·2	+ 8 7·55						+2 58	+1·97
22 19	7 33 37	19 17 21·2	+ 8 12·76	+3·55						
23 7				+2·95	6 58 50·8	+ 8 14·22	19 4 59	11 60·05	+2·58	+3·19
23 18					18 6 39·6	+ 8 15·65	6 14 39	11 59·98	+3·24	
24 8	19 59 26	7 37 9·6	+ 8 17·34	+2·95					+2·49	+2·71
24 19	7 49 24	19 25 10·0	+ 8 19·51	+4·37						
25 8				+2·90	8 8 36·0	+ 8 21·21	20 22 55	11 60·66	+2·49	+2·27
25 18					18 16 50·4	+ 8 22·56	6 32 51	11 60·29	+4·10	
26 8	20 27 15	7 56 58·0	+ 8 24·42	+2·90					+3·18	+3·53
26 19	7 19 12	18 47 6·8	+ 8 26·36	+4·29						
27 9				+2·48	8 53 0·4	+ 8 28·06	21 15 27	11 60·16	+3·18	+2·83
27 18					18 15 38·4	+ 8 29·20	6 39 39	11 59·64	+4·24	
28 8	20 23 31	7 44 18·8	+ 8 30·87	+2·48						+2·13

Concluded Longitude of Liverpool from Greenwich = 12m 0s·12.

Chronometer D.

Sep.										
20 18					18 8 57·2	+ 6 30·76	6 3 21	11 61·20		
21 7	20 12 0	8 3 9·6	+ 6 32·94						+6·10	+6·78
22 19	7 34 36	19 19 54·4	+ 6 38·40	+3·72						
23 7				+5·10	7 1 53·2	+ 6 40·81	19 6 29	11 59·28	+6·10	+5·42
23 18					18 11 4·0	+ 6 43·21	6 17 32	11 59·41	+4·89	
24 8	20 1 15	7 40 29·6	+ 6 46·03	+5·10					+5·13	+4·78
24 19	7 50 25	19 27 41·6	+ 6 48·74	+5·48						
25 8				+5·53	8 13 52·8	+ 6 51·27	20 26 44	11 59·14	+5·13	+5·48
25 18					18 26 6·0	+ 6 53·31	6 40 39	11 59·91	+3·00	
26 8	20 28 18	7 59 29·2	+ 6 56·05	+5·53					+5·56	+5·58
26 19	7 20 33	18 49 56·0	+ 6 57·95	+4·21						
27 9				+5·46	8 56 41·2	+ 7 0·78	21 17 42	11 59·05	+5·56	+5·54
27 18					18 19 37·6	+ 7 2·68	6 42 12	11 59·74	+3·09	
28 8	20 24 57	7 47 10·0	+ 7 5·44	+5·46						+5·38

Concluded Longitude of Liverpool from Greenwich = 11m 59s·48.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER E.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 20 4·8	+ 0 4·70	6 8 4	11 60·52		
21 7	20 13 18	8 10 55·6	+ 0 4·74						+1·04	+1·26
22 19	7 35 39	19 27 30·8	+ 0 4·84	+0·07						
23 7				+0·82	7 10 30·0	+ 0 5·28	19 8 30	11 59·89	+1·04	+0·82
23 18					18 19 33·6	+ 0 5·71	6 19 24	11 59·82	+1·08	
24 8	20 2 45	7 48 39·2	+ 0 6·20	+0·82					+0·40	+0·82
24 19	7 51 57	19 35 55·6	+ 0 6·49	+0·55						
25 8				+0·12	8 22 38·0	+ 0 6·48	20 28 44	11 59·87	+0·40	−0·02
25 18					18 35 1·6	+ 0 6·47	6 42 48	11 60·02	−0·38	
26 8	20 29 29	8. 7 29·6	+ 0 6·46	+0·12					+0·47	+0·26
26 19	7 21 45	18 57 58·8	+ 0 6·95	+1·08						
27 9				+0·10	9 6 14·0	+ 0 6·92	21 20 21	11 59·43	+0·47	+0·68
27 18					18 30 29·6	+ 0 6·90	6 46 9	11 59·61	−0·51	
28 8	20 25 59	7 55 10·4	+ 0 6·87	+0·10						−0·48

Concluded Longitude of Liverpool from Greenwich = 11m 59s·85.

CHRONOMETER F.

Sep.										
20 18					18 20 16·0	+ 2 46·06	6 10 56	11 61·55		
21 7	20 14 23	8 9 19·2	+ 2 45·95						+2·82	+2·80
22 19	7 36 46	19 25 56·8	+ 2 45·66	−0·20						
23 7				+2·24	7 10 0·8	+ 2 46·49	19 10 43	11 59·26	+2·82	+2·84
23 18					18 19 29·6	+ 2 47·30	6 22 2	11 59·84	+0·50	
24 8	20 3 40	7 46 52·0	+ 2 48·24	+2·24					+1·49	+1·64
24 19	7 53 13	19 34 29·2	+ 2 48·68	+0·86						
25 8				+1·39	8 22 45·6	+ 2 49·09	20 31 35	11 59·56	+1·49	+1·34
25 18					8 35 12·4	+ 2 49·42	6 45 42	11 60·25	−0·85	
26 8	20 30 51	8 6 8·0	+ 2 49·84	+1·39					+1·17	+1·44
26 19	7 23 8	18 56 38·0	+ 2 50·52	+1·51						
27 9				+1·07	9 5 18·0	+ 2 50·89	21 22 9	11 59·68	+1·17	+0·90
27 18					18 34 40·8	+ 2 51·14	6 53 5	11 60·19	−0·66	
28 8	20 27 7	7 53 33·6	+ 2 51·49	+1·07						+1·24

Concluded Longitude of Liverpool from Greenwich = 11m 59s·85.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer G.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 20 8·0	+ 5 14·24	6 13 18	11 60·11		
									+3·23	+2·60
21 7	20 15 49	8 8 15·2	+ 5 15·73							
				+2·57						
22 19	7 37 38	19 24 14·8	+ 5 19·51							
				+3·28					+3·23	+3·86
23 7					7 10 19·2	+ 5 21·23	19 13 36	11 59·87		
									+4·20	
23 18					18 19 8·4	+ 5 22·91	6 24 17	11 59·61		
				+3·28					+2·70	+2·70
24 8	20 4 34	7 45 9·2	+ 5 24·89							
				+3·28						
24 19	7 54 13	19 32 51·2	+ 5 26·52							
				+2·97					+2·70	+2·70
25 8					8 26 37·2	+ 5 28·11	20 38 6	11 60·24		
									+3·12	
25 18					18 33 41·2	+ 5 29·38	6 46 51	11 60·20		
				+2·97					+2·90	+3·24
26 8	20 31 46	8 4 21·6	+ 5 31·09							
				+3·58						
26 19	7 24 24	18 55 11·6	+ 5 32·71							
				+3·15					+2·90	+2·56
27 9					9 5 15·6	+ 5 34·70	21 24 50	11 60·54		
									+4·08	
27 18					18 34 13·6	+ 5 36·03	6 55 23	11 60·26		
				+3·15						+3·74
28 8	20 28 4	7 51 44·0	+ 5 37·93							

Concluded Longitude of Liverpool from Greenwich = $12^m\ 0^s{\cdot}07$.

Chronometer H.

Sep.										
20 18					18 12 55·6	+18 10·48	6 19 3	11 59·89		
									+6·98	+6·97
21 7	20 16 45	7 56 12·4	+18 14·38							
				+6·65						
22 19	7 38 46	19 12 18·0	+18 24·13							
				+6·80					+6·98	+6·99
23 7					7 2 6·0	+18 27·46	19 18 30	11 59·71		
									+7·38	
23 18					18 9 12·0	+18 30·71	6 27 29	11 59·55		
				+6·80					+6·72	+6·61
24 8	20 5 46	7 33 11·2	+18 34·70							
				+6·94						
24 19	7 55 18	19 20 44·4	+18 38·14							
				+6·98					+6·72	+6·83
25 8					8 15 16·8	+18 41·75	20 40 0	11 59·79		
									+6·30	
25 18					18 23 55·2	+18 44·55	6 50 21	11 59·94		
				+6·98					+6·90	+7·13
26 8	20 33 8	7 52 26·0	+18 48·47							
				+6·69						
26 19	7 25 45	18 43 13·6	+18 51·49							
				+6·60					+6·90	+6·67
27 9					8 54 4·8	+18 55·53	21 27 1	11 59·93		
									+7·97	
27 18					18 23 33·2	+18 58·24	6 58 6	11 59·50		
				+6·60						+6 53
28 8	20 29 4	7 39 19·6	+19 2·17							

Concluded Longitude of Liverpool from Greenwich = $11^m\ 59^s{\cdot}76$.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER I.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 30 48·0	+ 2 32·73	6 21 17	11 60·91		
21 7	20 17 41	8 12 50·0	+ 2 32·62						+1·51	+1·39
22 19	7 41 11	19 30 34·4	+ 2 32·33	−0·20						
23 7				+1·51	7 20 29·2	+ 2 32·75	19 20 59	11 59·61	+1·51	+1·63
23 18					18 27 2·0	+ 2 33·16	6 29 21	11 60·30	−0·61	
24 8	20 7 24	7 50 50·0	+ 2 33·63	+1·51					+1·22	+1·39
24 19	7 56 14	19 37 44·8	+ 2 33·58	−0·14						
25 8				+1·34	8 33 59·2	+ 2 33·98	20 42 35	11 59·84	+1·22	+1·05
25 18					18 42 43·6	+ 2 34·29	6 52 59	11 60·51	−0·85	
26 8	20 34 12	8 9 43·6	+ 2 34·69	+1·34					+1·48	+1·63
26 19	7 27 11	19 0 56·4	+ 2 34·45	−0·53						
27 9				+0·96	9 13 47·6	+ 2 34·82	21 30 24	11 59·57	+1·48	+1·33
27 18					18 42 34·4	+ 2 35·06	7 0 44	11 59·95	−0·36	
28 8	20 30 5	7 56 47·2	+ 2 35·41	+0·96						+0·59

Concluded Longitude of Liverpool from Greenwich = 11m 59s·99.

CHRONOMETER J.

Sep.										
20 18					18 32 2·0	+ 3 57·93	6 23 57	11 60·54		
21 7	20 19 34	8 13 16·4	+ 3 58·90						+3·06	+2·93
22 19	7 42 11	19 30 5·2	+ 4 1·37	+1·68						
23 7				+2·99	7 21 32·8	+ 4 2·70	19 23 33	11 59·58	+3·06	+3·19
23 18					18 27 50·4	+ 4 3·97	6 31 41	11 59·89	+2·08	
24 8	20 8 26	7 50 20·0	+ 4 5·47	+2·99					+2·48	+2·79
24 19	7 57 22	19 37 19·6	+ 4 6·60	+2·26						
25 8				+2·52	8 34 54·0	+ 4 7·77	20 45 4	11 59·85	+2·48	+2·17
25 18					18 44 14·4	+ 4 8·71	6 56 5	11 60·24	+1·31	
26 8	20 35 19	8 9 15·2	+ 4 9·91	+2·52					+2·95	+2·87
26 19	7 28 27	19 0 36·0	+ 4 10·66	+1·67						
27 9				+2·76	9 14 48·8	+ 4 12·11	21 33 3	11 59·49	+2·95	+3·03
27 18					18 44 47·6	+ 4 13·09	7 4 36	11 59·82	+1·65	
28 8	20 30 59	7 56 2·0	+ 4 14·46	+2·76						+2·49

Concluded Longitude of Liverpool from Greenwich = 11m 59s·83.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer K.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 37 27·6	+ 1 6·19	6 26 31	11 60·82		
21 7	20 20 47	8 17 20·8	+ 1 7·31						+3·85	+4·23
22 19	7 43 20	19 34 5·2	+ 1 10·18	+1·95						
23 7				+3·03	7 26 45·2	+ 1 11·38	19 25 55	11 59·05	+3·85	+3·47
23 18					18 33 21·2	+ 1 12·53	6 34 21	11 59·69	+1·10	
24 8	20 9 37	7 54 22·4	+ 1 13·87	+3·03					+2·28	+2·59
24 19	7 59 16	19 42 4·8	+ 1 15·09	+2·44						
25 8				+2·35	8 40 4·0	+ 1 16·23	20 47 23	11 59·68	+2·28	+1·97
25 18					18 50 1·2	+ 1 17·15	6 59 1	11 59·96	+1·51	
26 8	20 41 30	8 18 16·8	+ 1 18·31	+2·35					+2·91	+2·73
26 19	7 29 58	19 4 57·6	+ 1 19·82	+3·34						
27 9				+2·62	9 22 7·6	+ 1 21·15	21 37 32	11 59·07	+2·91	+3·09
27 18					18 50 40·8	+ 1 22·05	7 7 39	11 59·48	+1·24	
28 8	20 32 0	7 59 54·0	+ 1 23·29	+2·62						+2·15

Concluded Longitude of Liverpool from Greenwich = 11m 59s·56.

Chronometer K*.

Sep.										
20 18					18 37 47·8	+ 5 57·26	6 31 43	11 60·94		
21 7	20 22 3	8 13 45·0	+ 5 58·92						+4·47	+4·85
22 19	7 45 44	19 31 35·8	+ 6 3·18	+2·90						
23 7				+3·65	7 25 28·6	+ 6 5·30	19 29 32	11 59·95	+4·47	+4·09
23 18					18 31 45·4	+ 6 7·35	6 37 41	11 59·26	+5·96	
24 8	20 11 27	7 51 16·2	+ 6 9·76	+3·65					+3·67	+3·21
24 19	8 0 14	19 38 5·4	+ 6 12·33	+5·18						
25 8				+4·95	8 37 57·4	+ 6 15·09	20 50 15	11 60·41	+3·67	+4·13
25 18					18 47 7·0	+ 6 17·25	7 1 7	11 60·21	+5·60	
26 8	20 42 25	8 14 9·8	+ 6 20·16	+4·95					+5·38	+5·77
26 19	7 31 18	19 1 15·4	+ 6 21·80	+3·63						
27 9				+4·31	9 19 19·4	+ 6 24·67	21 39 47	11 59·76	+5·38	+4·99
27 18					18 49 30·2	+ 6 26·65	7 11 34	11 59·13	+6·60	
28 8	20 32 58	7 55 45·8	+ 6 29·33	+4·31						+3·63

Concluded Longitude of Liverpool from Greenwich = 11m 59s·85.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer M.

Comparisons at Greenwich.				Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 46 28·0	+ 0 34·99	6 35 2	11 60·42		
									−0·03	−0·23
21 7	20 23 34	8 20 40·0	+ 0 34·66							
				−0·58						
22 19	7 46 49	19 38 10·0	+ 0 33·81							
				−0·14					−0·03	+0·17
23 7					7 34 59·6	+ 0 33·85	19 33 32	11 60·16		
									+0·59	
23 18					18 40 32·0	+ 0 33·89	6 40 54	11 59·93		
				−0·14					−0·76	−0·45
24 8	20 12 56	7 58 20·8	+ 0 33·93							
				+1·10						
24 19	8 1 45	19 45 14·0	+ 0 34·49							
				−0·50					−0·76	−1·07
25 8					8 46 2·0	+ 0 34·22	20 52 39	11 60·54		
									−0·48	
25 18					18 55 1·2	+ 0 34·01	7 3 18	11 60·53		
				−0·50					+0·18	+0·07
26 8	20 43 43	8 21 14·0	+ 0 33·74							
				−0·35						
26 19	7 32 37	19 8 22·4	+ 0 33·58							
				+0·03					+0·18	+0·29
27 9					9 27 26·4	+ 0 33·64	21 42 3	11 60·10		
									+0·30	
27 18					18 59 30·4	+ 0 33·67	7 15 41	11 60·01		
				+0·03						−0·23
28 8	20 34 12	8 2 55·2	+ 0 33·73							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·21.

Chronometer N.

Sep.										
20 18					18 47 8·0	+ 2 53·13	6 38 1	11 60·04		
									+3·75	+4·14
21 7	20 25 25	8 20 10·4	+ 2 54·96							
				+3·27						
22 19	7 48 20	19 37 14·8	+ 2 59·77							
				+3·16					+3·75	+3·36
23 7					7 34 58·0	+ 3 1·34	19 35 59	11 59·45		
									+3·07	
23 18					18 40 53·2	+ 3 2·79	6 43 45	11 59·48		
				+3·16					+3·68	+2·96
24 8	20 14 16	7 57 10·0	+ 3 4·51							
				+5·70						
24 19	8 2 44	19 43 40·0	+ 3 7·34							
				+4·17					+3·68	+4·40
25 8					9 14 8·4	+ 3 9·50	21 23 27	11 59·26		
									+2·93	
25 18					18 55 12·8	+ 3 11·07	7 6 8	11 59·65		
				+4·17					+3·54	+3·94
26 8	20 44 37	8 19 28·4	+ 3 13·20							
				+1·62						
26 19	7 39 4	19 12 8·0	+ 3 13·93							
				+3·48					+3·54	+3·14
27 9					9 27 47·2	+ 3 15·88	21 45 7	11 59·63		
									+2·68	
27 18					18 58 54·4	+ 3 17·16	7 17 49	11 59·85		
				+3·48						+3·82
28 8	20 35 19	8 1 16·8	+ 3 18·95							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·56.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer O.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 37 2·0	+15 49·33	6 40 52	11 59·71		
21 7	20 26 42	8 8 30·8	+15 51·35						+3·33	+3·08
22 19	7 49 25	19 25 22·8	+15 56·59	+3·57						
23 7				+3·45	7 25 2·0	+15 58·31	19 39 0	11 59·92	+3·33	+3·58
23 18					18 30 14·0	+15 59·97	6 46 3	11 59·85	+3·76	
24 8	20 15 26	7 45 22·4	+16 1·93	+3·45					+2·82	+3·32
24 19	8 4 4	19 32 4·0	+16 3·11	+2·36						
25 8				+2·62	9 3 40·8	+16 4·77	21 25 54	11 60·34	+2·82	+2·32
25 18					18 44 50·8	+16 5·97	7 8 41	11 59·96	+3·93	
26 8	20 45 42	8 7 38·8	+16 7·62	+2·62					+3·00	+2·92
26 19	7 39 53	19 0 1·6	+16 9·20	+3·50						
27 9				+2·76	9 17 10·0	+16 10·93	21 47 25	11 59·86	+3·00	+3·08
27 18					19 4 27·2	+16 12·12	7 36 20	11 59·65	+3·45	
28 8	20 36 42	7 49 44·8	+16 13·72	+2·76						+2·44

Concluded Longitude of Liverpool from Greenwich = $11^m\ 59^s{\cdot}94$.

Chronometer P.

Sep.										
20 18					19 14 2·0	−13 40·62	6 48 23	11 59·99		
21 7	20 3 27	8 14 54·0	−13 43·07						−5·25	−5·32
22 19	7 31 4	19 36 51·2	−13 49·82	−4·60						
23 7				−5·27	7 57 58·8	−13 52·91	19 42 6	11 60·01	−5·25	−5·18
23 18					19 3 52·8	−13 55·61	6 49 46	11 60·68	−7·28	
24 8	19 57 20	7 57 20·0	−13 58·72	−5·27					−5·20	−5·36
24 19	7 45 47	19 43 54·8	−14 1·71	−6·12						
25 8				−4·70	9 37 4·8	−14 4·52	21 29 9	11 60·58	−5·20	−5·04
25 18					19 18 13·6	−14 6·58	7 11 51	11 60·73	−5·49	
26 8	20 47 23	8 39 36·4	−14 9·25	−4·70					−4·45	−4·36
26 19	7 41 1	19 31 30·4	−14 11·79	−5·65						
27 9				−4·68	9 51 34·4	−14 14·81	21 51 24	11 60·17	−4·45	−4·54
27 18					19 36 26·8	−14 16·87	7 37 50	11 60·50	−5·90	
28 8	20 22 57	8 6 35·2	−14 19·43	−4·68						−4·82

Concluded Longitude of Liverpool from Greenwich = $12^m\ 0^s{\cdot}40$.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER Q.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 0 54·4	+ 2 41·00	6 51 38	11 59·54		
									−3·90	−5·11
21 7	20 6 18	8 1 22·0	+ 2 39·47							
				−2·82						
22 19	7 32 39	19 22 0·8	+ 2 35·32							
				−3·94					−3·90	−2·69
23 7					7 45 46·0	+ 2 33·16	19 46 20	11 59·97		
									−4·90	
23 18					18 51 2·0	+ 2 31·19	6 53 23	11 60·27		
				−3·94					−4·28	−5·19
24 8	19 58 21	7 41 53·2	+ 2 28·91							
				−1·71						
24 19	7 47 3	19 28 40·8	+ 2 28·09							
				−2·51					−4·28	−3·37
25 8					9 22 56·0	+ 2 26·82	21 31 31	11 61·51		
									−1·19	
25 18					19 4 28·0	+ 2 25·95	7 14 38	11 61·12		
				−2·51					−3·08	−1·65
26 8	20 48 24	8 24 3·2	+ 2 24·77							
				−2·90						
26 19	7 42 0	19 15 54·0	+ 2 23·46							
				−3·45					−3·08	−4·51
27 9					9 37 40·0	+ 2 21·94	21 54 5	11 61·97		
									+0·02	
27 18					19 23 44·8	+ 2 20·90	7 41 46	11 60·92		
				−3·45						−2·39
28 8	20 24 1	7 51 0·0	+ 2 19·60							

Concluded Longitude of Liverpool from Greenwich = 12ᵐ 0ˢ·82.

CHRONOMETER R.

Sep.										
20 18					19 5 5·6	+ 0 42·08	6 53 50	11 60·18		
									+6·52	+6·03
21 7	20 8 4	8 5 2·0	+ 0 45·18							
				+5·70						
22 19	7 33 39	19 24 42·4	+ 0 53·56							
				+6·65					+6·52	+7·01
23 7					7 49 41·6	+ 0 57·09	19 48 40	11 59·88		
									+7·38	
23 18					18 55 40·8	+ 1 0·26	6 56 32	11 59·65		
				+6·65					+6·09	+6·29
24 8	19 59 27	7 44 24·0	+ 1 3·93							
				+7·60						
24 19	7 48 16	19 31 14·0	+ 1 7·68							
				+6·28					+6·09	+5·89
25 8					9 26 26·8	+ 1 11·38	21 33 48	11 60·24		
									+6·82	
25 18					19 7 49·6	+ 1 14·02	7 16 49	11 60·14		
				+6·28					+6·51	+6·67
26 8	20 49 47	8 26 33·2	+ 1 17·55							
				+6·01						
26 19	7 43 5	19 18 2·0	+ 1 20·27							
				+6·45					+6·51	+6·35
27 9					9 41 16·4	+ 1 24·38	21 56 46	11 60·24		
									+7·85	
27 18					19 27 26·0	+ 1 27·12	7 44 35	11 59·80		
				+6·45						+6·55
28 8	20 24 53	7 52 40·8	+ 1 30·66							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·97.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer S.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 57 38·8	+11 10·87	6 56 53	11 59·67		
									+7·65	+7·52
21 7	20 9 19	7 55 46·8	+11 15·18							
				+7·88						
22 19	7 34 56	19 15 26·0	+11 26·75							
				+7·19					+7·65	+7·78
23 7					7 49 29·2	+11 30·09	19 59 3	11 59·17		
									+4·81	
23 18					18 46 56·0	+11 33·02	6 58 20	11 59·91		
				+7·19					+6·80	+6·60
24 8	20 0 45	7 35 9·2	+11 36·53							
				+9·13						
24 19	7 49 50	19 22 14·4	+11 41·04							
				+7·46					+6·80	+7·00
25 8					9 18 4·4	+11 44·93	21 36 0	11 59·74		
									+5·02	
25 18					19 0 2·8	+11 47·73	7 19 36	11 60·51		
				+7·46					+7·50	+7·92
26 8	20 51 6	8 17 18·0	+11 51·53							
				+8·20						
26 19	7 44 37	19 8 58·8	+11 55·23							
				+7·12					+7·50	+7·08
27 9					9 36 24·0	+11 59·14	22 2 30	11 59·54		
									+4·92	
27 18					19 18 58·4	+12 1·75	7 46 42	11 60·17		
				+7·12						+7·16
28 8	20 26 25	7 43 38·0	+12 5·20							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·86.

Chronometer T.

Sep.										
20 18					19 14 29·2	− 2 30·76	7 0 2	11 59·96		
									−7·00	−7·41
21 7	20 11 1	8 11 18·4	− 2 34·69							
				−7·30						
22 19	7 36 6	19 30 48·0	− 2 45·43							
				−6·88					−7·00	−6·59
23 7					8 8 53·2	− 2 49·02	20 4 8	11 59·90		
									−6·63	
23 18					19 5 20·4	− 2 52·10	7 2 20	11 59·84		
				−6·88					−7·18	−7·17
24 8	20 2 17	7 51 13·2	− 2 55·73							
				−6·70						
24 19	7 51 15	19 38 19·2	− 2 59·00							
				−6·70					−7·18	−7·19
25 8					9 35 18·4	− 3 2·83	21 38 26	11 60·39		
									−6·06	
25 18					19 19 10·0	− 3 5·49	7 23 51	11 60·18		
				−6·70					−6·45	−6·21
26 8	20 52 14	8 33 26·4	− 3 9·05							
				−7·45						
26 19	7 46 10	19 25 39·2	− 3 12·42							
				−6·72					−6·45	−6·69
27 9					9 54 35·6	− 3 16·20	22 5 26	11 60·28		
									−5·08	
27 18					19 37 24·0	− 3 18·79	7 49 48	11 59·74		
				−6·72						−6·75
28 8	20 27 40	8 0 20·0	− 3 21·99							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·01.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER U.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 6 50·0	+ 8 18·69	7 3 12	11 60·72		
21 7	20 12 2	8 1 22·8	+ 8 21·74						+6·70	+7·62
22 19	7 37 22	19 20 48·4	+ 8 29·95	+5·60						
23 7				+5·39	7 59 53·6	+ 8 32·85	20 6 31	11 59·55	+6·70	+5·78
23 18					18 56 8·0	+ 8 35·43	7 4 36	11 59·34	+6·12	
24 8	20 3 41	7 41 2·8	+ 8 38·44	+5·39					+4·82	+5·00
24 19	7 53 1	19 28 22·8	+ 8 43·12	+9·50						
25 8				+4·67	9 26 13·6	+ 8 46·02	21 41 11	11 59·89	+4·82	+4·64
25 18					19 9 52·4	+ 8 48·01	7 26 28	11 59·51	+5·84	
26 8	20 56 53	8 26 4·8	+ 8 50·79	+4·67					+5·23	+4·70
26 19	7 47 18	19 14 41·2	+ 8 53·40	+5·79						
27 9				+5·58	9 44 25·6	+ 8 56·39	22 7 30	11 59·21	+5·23	+5·76
27 18					19 27 17·6	+ 8 58·38	7 51 59	11 59·86	+3·32	
28 8	20 28 54	7 49 10·8	+ 9 1·00	+5·58						+5·40

Concluded Longitude of Liverpool from Greenwich = 11m 59s·67.

CHRONOMETER W.

Sep.										
20 18					19 33 23·0	−16 49·90	7 4 38	11 59·37		
21 7	20 13 24	8 27 59·4	−16 53·08						−6·37	−6·28
22 19	7 38 30	19 47 28·2	−17 2·03	−6·09						
23 7				−6·45	8 28 31·4	−17 5·56	20 9 31	11 59·44	−6·37	−6·46
23 18					19 24 19·8	−17 8·52	7 7 4	11 59·59	−6·84	
24 8	20 4 49	8 8 1·0	−17 11·95	−6·45					−7·00	−6·44
24 19	7 54 6	19 55 25·8	−17 15·06	−6·38						
25 8				−7·49	9 56 59·0	−17 19·43	21 45 52	11 59·61	−7·00	−7·56
25 18					19 38 1·4	−17 22·40	7 28 27	11 59·43	−6·91	
26 8	20 59 10	8 54 38·6	−17 26·38	−7·49					−6·93	−7·42
26 19	7 49 5	19 42 50·6	−17 29·30	−6·44						
27 9				−6·70	10 12 58·2	−17 33·21	22 9 33	11 59·55	−6·93	−6·44
27 18					19 55 37·8	−17 35·83	7 53 46	11 59·15	−5·48	
28 8	20 30 20	8 17 16·6	−17 39·03	−6·70						−6·96

Concluded Longitude of Liverpool from Greenwich = 11m 59s·45.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer S.

Approximate Solar Time, 1844.	Comparisons at Greenwich: Time by Greenwich Transit Clock.	Comparisons at Greenwich: Corresponding Time by Chronometer.	Comparisons at Greenwich: Chronometer Slow.	Comparisons at Greenwich: Chronometer's Apparent Losing Rate.	Comparisons at Liverpool: Time by Chronometer.	Comparisons at Liverpool: Chronometer Error employed.	Comparisons at Liverpool: Corresponding Time by Liverpool Transit Clock.	Comparisons at Liverpool: Resulting Difference of Longitude.	Comparisons at Liverpool: Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					18 57 38·8	+11 10·87	6 56 53	11 59·67		
									+7·65	+7·52
21 7	20 9 19	7 55 46·8	+11 15·18							
				+7·88						
22 19	7 34 56	19 15 26·0	+11 26·75							
				+7·19					+7·65	+7·78
23 7					7 49 29·2	+11 30·09	19 59 3	11 59·17		
									+4·81	
23 18					18 46 56·0	+11 33·02	6 58 20	11 59·91		
				+7·19					+6·80	+6·60
24 8	20 0 45	7 35 9·2	+11 36·53							
				+9·13						
24 19	7 49 50	19 22 14·4	+11 41·04							
				+7·46					+6·80	+7·00
25 8					9 18 4·4	+11 44·93	21 36 0	11 59·74		
									+5·02	
25 18					19 0 2·8	+11 47·73	7 19 36	11 60·51		
				+7·46					+7·50	+7·92
26 8	20 51 6	8 17 18·0	+11 51·53							
				+8·20						
26 19	7 44 37	19 8 58·8	+11 55·23							
				+7·12					+7·50	+7·08
27 9					9 36 24·0	+11 59·14	22 2 30	11 59·54		
									+4·92	
27 18					19 18 58·4	+12 1·75	7 46 42	11 60·17		
				+7·12						+7·16
28 8	20 26 25	7 43 38·0	+12 5·20							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·86.

Chronometer T.

Sep.										
20 18					19 14 29·2	− 2 30·76	7 0 2	11 59·96		
									−7·00	−7·41
21 7	20 11 1	8 11 18·4	− 2 34·69							
				−7·30						
22 19	7 36 6	19 30 48·0	− 2 45·43							
				−6·88					−7·00	−6·59
23 7					8 8 53·2	− 2 49·02	20 4 8	11 59·90		
									−6·63	
23 18					19 5 20·4	− 2 52·10	7 2 20	11 59·84		
				−6·88					−7·18	−7·17
24 8	20 2 17	7 51 13·2	− 2 55·73							
				−6·70						
24 19	7 51 15	19 38 19·2	− 2 59·00							
				−6·70					−7·18	−7·19
25 8					9 35 18·4	− 3 2·83	21 38 26	11 60·39		
									−6·06	
25 18					19 19 10·0	− 3 5·49	7 23 51	11 60·18		
				−6·70					−6·45	−6·21
26 8	20 52 14	8 33 26·4	− 3 9·05							
				−7·45						
26 19	7 46 10	19 25 39·2	− 3 12·42							
				−6·72					−6·45	−6·69
27 9					9 54 35·6	− 3 16·20	22 5 26	11 60·28		
									−5·08	
27 18					19 37 24·0	− 3 18·79	7 49 48	11 59·74		
				−6·72						−6·75
28 8	20 27 40	8 0 20·0	− 3 21·99							

Concluded Longitude of Liverpool from Greenwich = 12ᵐ 0ˢ·01.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER U.

Approximate Solar Time, 1844.	Comparisons at Greenwich. Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Comparisons at Liverpool. Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 6 50·0	+ 8 18·69	7 3 12	11 60·72		
									+6·70	+7·62
21 7	20 12 2	8 1 22·8	+ 8 21·74							
				+5·60						
22 19	7 37 22	19 20 48·4	+ 8 29·95							
				+5·39					+6·70	+5·78
23 7					7 59 53·6	+ 8 32·85	20 6 31	11 59·55		
									+6·12	
23 18					18 56 8·0	+ 8 35·43	7 4 36	11 59·34		
				+5·39					+4·82	+5·00
24 8	20 3 41	7 41 2·8	+ 8 38·44							
				+9·50						
24 19	7 53 1	19 28 22·8	+ 8 43·12						+4·82	+4·64
				+4·67						
25 8					9 26 13·6	+ 8 46·02	21 41 11	11 59·89		
									+5·84	
25 18					19 9 52·4	+ 8 48·01	7 26 28	11 59·51		
				+4·67					+5·23	+4·70
26 8	20 56 53	8 26 4·8	+ 8 50·79							
				+5·79						
26 19	7 47 18	19 14 41·2	+ 8 53·40							
				+5·58					+5·23	+5·76
27 9					9 44 25·6	+ 8 56·39	22 7 30	11 59·21		
									+3·32	
27 18					19 27 17·6	+ 8 58·38	7 51 59	11 59·86		
				+5·58						+5·40
28 8	20 28 54	7 49 10·8	+ 9 1·00							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·67.

CHRONOMETER W.

Sep.										
20 18					19 33 23·0	−16 49·90	7 4 38	11 59·37		
									−6·37	−6·28
21 7	20 13 24	8 27 59·4	−16 53·08							
				−6·09						
22 19	7 38 30	19 47 28·2	−17 2·03							
				−6·45					−6·37	−6·46
23 7					8 28 31·4	−17 5·56	20 9 31	11 59·44		
									−6·84	
23 18					19 24 19·8	−17 8·52	7 7 4	11 59·59		
				−6·45					−7·00	−6·44
24 8	20 4 49	8 8 1·0	−17 11·95							
				−6·38						
24 19	7 54 6	19 55 25·8	−17 15·06							
				−7·49					−7·00	−7·56
25 8					9 56 59·0	−17 19·43	21 45 52	11 59·61		
									−6·91	
25 18					19 38 1·4	−17 22·40	7 28 27	11 59·43		
				−7·49					−6·93	−7·42
26 8	20 59 10	8 54 38·6	−17 26·38							
				−6·44						
26 19	7 49 5	19 42 50·6	−17 29·30							
				−6·70					−6·93	−6·44
27 9					10 12 58·2	−17 33·21	22 9 33	11 59·55		
									−5·48	
27 18					19 55 37·8	−17 35·83	7 53 46	11 59·15		
				−6·70						−6·96
28 8	20 30 20	8 17 16·6	−17 39·03							

Concluded Longitude of Liverpool from Greenwich = 11ᵐ 59ˢ·45.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer X.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 20 41·8	− 1 22·63	7 7 24	11 59·89		
									+0·22	+0·59
21 7	20 14 36	8 13 40·6	− 1 22·48							
				+0·29						
22 19	7 41 4	19 34 21·8	− 1 22·05							
				−0·16					+0·22	−0·15
23 7					8 16 50·6	− 1 22·14	20 13 34	11 59·72		
									−0·24	
23 18					19 11 20·2	− 1 22·23	7 9 51	11 59·74		
									−0·25	−0·17
24 8	20 5 56	7 53 18·2	− 1 22·33	−0·16						
				+0·98						
24 19	7 55 9	19 40 35·4	− 1 21·83							
				−0·48					−0·25	0·33
25 8					9 44 12·2	− 1 22·02	21 49 3	11 59·74		
									+0·12	
25 18					19 23 49·0	− 1 22·14	7 30 15	11 59·57		
				−0·48					−0·46	−0·63
26 8	21 0 5	8 39 29·4	− 1 22·33							
				+0·44						
26 19	7 50 26	19 28 4·2	− 1 22·13							
				−0·41					−0·46	−0·29
27 9					9 59 41·0	− 1 22·39	22 12 27	11 59·64		
									−0·50	
27 18					19 42 10·6	− 1 22·57	7 56 32	11 59·66		
				−0·41						−0·53
28 8	20 31 16	8 1 56·2	− 1 22·79							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·72.

Chronometer Y.

Sep.										
20 18					19 14 21·0	+ 7 20·75	7 9 46	11 60·87		
									+4·79	+4·95
21 7	20 15 39	8 5 58·2	+ 7 22·75							
				+3·70						
22 19	7 42 6	19 26 33·4	+ 7 28·19							
				+4·65					+4·79	+4·63
23 7					8 11 7·8	+ 7 30·59	20 16 44	11 60·17		
									+4·38	
23 18					19 5 3·4	+ 7 32·65	7 12 29	11 60·25		
				+4·65					+4·95	+4·67
24 8	20 7 2	7 45 26·6	+ 7 35·09							
				+6·25						
24 19	7 56 14	19 32 40·2	+ 7 38·18							
				+4·97					+4·95	+5·23
25 8					9 38 53·8	+ 7 41·10	21 52 48	11 60·08		
									+5·22	
25 18					19 17 1·8	+ 7 43·15	7 32 33	11 60·04		
				+4·97					+4·60	+4·71
26 8	21 1 1	8 31 17·0	+ 7 45·92							
				+5·10						
26 19	7 52 1	19 20 28·6	+ 7 48·22							
				+4·75					+4·60	+4·49
27 9					9 53 5·8	+ 7 50·83	22 15 5	11 60·09		
									+3·15	
27 18					19 35 7·0	+ 7 52·57	7 58 43	11 60·56		
				+4·75						+5·01
28 8	20 32 29	7 53 51·4	+ 7 54·81							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·20.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

CHRONOMETER Z.

Comparisons at Greenwich.				Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 21 3·4	+ 4 18·86	7 13 28	11 59·98		
									+1·94	+0·31
21 7	20 16 50	8 10 12·6	+ 4 19·16							
				+0·57						
22 19	7 43 10	19 30 45·4	+ 4 20·00							
				+2·77					+1·94	+3·57
23 7					8 16 53·0	+ 4 21·29	20 19 21	11 59·50		
									+1·63	
23 18					19 11 7·8	+ 4 22·42	7 15 24	11 59·89		
				+2·77					+1·01	+1·97
24 8	20 8 22	7 49 57·8	+ 4 23·68							
				+0·61						
24 19	7 57 24	19 37 4·2	+ 4 24·00							
				+1·22					+1·01	+0·05
25 8					9 44 57·4	+ 4 24·83	21 55 35	11 60·86		
									+1·93	
25 18					19 23 46·6	+ 4 25·39	7 36 0	11 60·65		
				+1·22					+2·03	+2·39
26 8	21 1 59	8 35 34·6	+ 4 26·16							
				+1·71						
26 19	7 53 46	19 25 34·6	+ 4 26·93							
				+1·62					+2·03	+1·67
27 9					9 59 18·2	+ 4 27·98	22 17 55	11 60·10		
									+1·98	
27 18					19 40 29·0	+ 4 28·67	8 0 42	11 59·99		
				+1·62						+1·57
28 8	20 34 8	7 58 55·4	+ 4 29·55							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·09.

CHRONOMETER *a*.

Sep.										
20 18					19 26 17·4	+ 1 17·84	7 15 40	11 61·33		
									+2·00	+1·37
21 7	20 17 46	8 14 10·2	+ 1 17·40							
				−0·70						
22 19	7 44 40	19 35 19·0	+ 1 16·16							
				+1·58					+2·00	+2·63
23 7					8 22 20·0	+ 1 16·25	20 21 44	11 58·85		
									−3·14	
23 18					19 16 23·0	+ 1 16·32	7 17 33	11 60·35		
				+1·58					+1·42	+0·53
24 8	20 10 1	7 54 43·8	+ 1 16·40							
				−0·49						
24 19	7 58 44	19 41 31·8	+ 1 16·18							
				+2·17					+1·42	+2·31
25 8					9 50 50·6	+ 1 16·94	21 58 22	11 59·62		
									−1·19	
25 18					19 29 59·0	+ 1 17·46	7 39 5	11 60·62		
				+2·17					+0·77	+2·03
26 8	21 3 6	8 39 49·4	+ 1 18·17							
				−1·44						
26 19	7 55 4	19 30 1·8	+ 1 17·52							
				+0·98					+0·77	−0·49
27 9					10 4 50·6	+ 1 17·83	22 20 17	11 60·74		
									−0·82	
27 18					19 46 51·4	+ 1 18·03	8 3 53	11 61·27		
				+0·98						+2·45
28 8	20 35 45	8 3 43·4	+ 1 18·29							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·21.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer *b*.

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 26 28·2	+ 4 36·11	7 19 11	11 59·96		
									+3·01	+2·59
21 7	20 19 1	8 12 5·0	+ 4 37·40							
				+2·40						
22 19	7 46 3	19 33 17·0	+ 4 40·93						+3·01	+3·43
				+3·13						
23 7					8 22 3·0	+ 4 42·27	20 24 53	11 59·38		
									+1·05	
23 18					19 21 26·2	+ 4 43·44	7 26 5	11 60·07		
				+3·13					+2·81	+2·83
24 8	20 11 38	7 52 52·2	+ 4 44·73							
				+1·99						
24 19	8 0 17	19 39 35·0	+ 4 45·73							
				+2·84					+2·81	+2·79
25 8					9 49 57·0	+ 4 47·24	22 0 59	11 59·75		
									+1·85	
25 18					19 28 54·2	+ 4 48·29	7 41 32	11 60·06		
				+2·84					+2·49	+2·89
26 8	21 8 30	8 41 41·0	+ 4 49·71							
				+0·98						
26 19	7 56 6	19 27 31·0	+ 4 50·15							
				+2·33					+2·49	+2·09
27 9					10 3 17·8	+ 4 51·40	22 22 19	11 59·83		
									+1·29	
27 18					19 46 8·6	+ 4 52·22	8 6 46	11 60·13		
				+2·33						+2·57
28 8	20 37 1	8 1 24·2	+ 4 53·28							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·88.

Chronometer *d*.

Sep.										
20 18					19 33 3·0	+ 3 25·90	7 24 37	11 59·44		
									+5·40	+5·05
21 7	20 24 48	8 18 59·625	+ 3 28·835							
				+5·49						
22 19	7 47 11	19 35 28·875	+ 3 36·885							
				+5·39					+5·40	+5·75
23 7					8 26 51·0	+ 3 39·84	20 28 39	11 59·57		
									+5·88	
23 18					19 29 7·5	+ 3 42·37	7 32 47	11 59·40		
				+5·39					+4·78	+5·03
24 8	20 12 39	7 54 52·5	+ 3 45·28							
				+4·47						
24 19	8 1 44	19 42 0·0	+ 3 47·50							
				+5·10					+4·78	+4·53
25 8					9 56 57·0	+ 3 50·65	22 7 3	11 60·15		
									+6·05	
25 18					19 32 59·0	+ 3 52·82	7 44 42	11 59·90		
				+5·10					+5·42	+5·67
26 8	21 9 44	8 43 48·75	+ 3 55·75							
				+6·22						
26 19	7 57 29	19 29 45·375	+ 3 58·555							
				+4·80					+5·42	+5·17
27 9					10 6 12·0	+ 4 1·80	22 24 24	11 59·78		
									+6·95	
27 18					19 49 7·5	+ 4 3·97	8 8 58	11 59·14		
				+4·80						+4·43
28 8	20 37 53	8 3 2·625	+ 4 6·715							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·68.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM GREENWICH.

Chronometer *e.*

Comparisons at Greenwich.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Sep. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 18					19 42 7·5	− 2 12·30	7 28 5	11 58·31		
									−8·37	−10·66
21 7	20 26 9	8 26 6·0	−2 16·76							
				−8·42						
22 19	7 48 48	19 43 11·625	−2 29·135						−8·37	−6·08
				−7·34						
23 7					8 37 22·5	− 2 32·25	20 32 59	11 59·70	−2·12	
23 18					19 37 51·0	− 2 34·91	7 35 15	11 58·01		
				−7·34					−7·86	−8·60
24 8	20 14 12	8 2 48·375	−2 37·855							
				−7·05						
24 19	8 2 51	19 49 35·625	−2 41·305						−7·86	−7·12
				−6·18						
25 8					10 7 23·0	− 2 44·94	22 10 54	11 60·19	−6·08	
25 18					19 42 30·0	− 2 47·44	7 47 33	11 60·12		
				−6·18					−6·42	−5·24
26 8	21 10 43	8 51 34·125	−2 50·785							
				−11·18						
26 19	7 59 0	19 38 10·5	−2 55·82						−6·42	−7·60
				−5·42						
27 9					10 16 19·5	− 2 58·68	22 27 30	11 61·32	−2·75	
27 18					19 58 51·0	− 3 0·62	8 11 36	11 60·49		
				−5·42						−3·24
28 8	20 39 3	8 11 22·125	−3 2·985							

Concluded Longitude of Liverpool from Greenwich = 11m 59s·61.

Chronometer *f.*

Sep.										
20 18					19 52 6·0	− 6 7·27	7 34 7	11 60·83		
									−5·15	−5·19
21 7	20 27 34	8 31 24·75	−6 10·75							
				−6·66						
22 19	7 50 25	19 48 39·75	−6 20·53						−5·15	−5·11
				−5·50						
23 7					8 43 52·5	− 6 23·67	20 35 38	11 59·71	−6·23	
23 18					19 46 42·5	− 6 26·27	7 40 14	11 59·97		
				−5·50					−5·08	−5·89
24 8	20 15 28	8 7 55·5	−6 29·18							
				−7·54						
24 19	8 3 57	19 54 33·0	−6 32·87						−5·08	−4·27
				−4·27						
25 8					10 17 13·5	− 6 36·02	22 16 55	11 59·59	−7·85	
25 18					19 53 33·0	− 6 38·08	7 54 46	11 60·66		
				−4·27					−4·95	−4·27
26 8	21 12 4	8 56 45·0	−6 40·88							
				−6·66						
26 19	8 0 8	19 43 6·375	−6 43·885						−4·95	−5·63
				−5·10						
27 9					10 29 10·5	− 6 47·18	22 36 35	11 60·29	−6·12	
27 18					20 7 39·0	− 6 49·38	8 16 36	11 60·55		
				−5·10						−4·57
28 8	20 40 22	8 16 30·0	−6 52·07							

Concluded Longitude of Liverpool from Greenwich = 12m 0s·11.

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In the following Table, the Results from all the Chronometers are collected.

Reference to Chronometer.	Longitude of Liverpool West of Greenwich.	Sum of Squares of Changes of Travelling Rates.	Sum of Squares of Changes of Stationary Rates.	Weight of Result.
	m s			
A	11 59·87	0·1628	1·1519	730
B	11 59·87	1·1128	1·8801	297
C	11 60·12	4·4800	1·4845	134
D	11 59·48	2·7864	10·5859	70
E	11 59·85	2·4996	6·8256	98
F	11 59·85	1·9488	13·8222	61
G	11 60·07	5·0796	3·9905	93
H	11 59·76	0·5144	2·9266	277
I	11 59·99	1·2048	1·0244	380
J	11 59·83	1·4192	1·2249	321
K	11 59·56	3·3272	11·1419	64
*K**	11 59·85	7·3460	22·8502	31
M	11 60·21	2·5472	4·5648	126
N	11 59·56	4·1560	17·4695	43
O	11 59·94	2·1128	4·6484	134
P	11 60·40	0·7276	9·0130	100
Q	11 60·82	31·0512	26·2234	15
R	11 59·97	2·3896	7·5209	93
S	11 59·86	3·1784	65·8502	14
T	11 60·01	2·2036	8·4124	88
U	11 59·67	5·3804	31·1938	26
W	11 59·45	2·5376	2·1975	179
X	11 59·72	0·8368	3·4949	217
Y	11 60·20	1·0068	8·8371	98
Z	11 60·09	22·8780	4·0277	29
a	11 60·21	24·2384	13·9130	22
b	11 59·88	1·9476	3·5787	162
d	11 59·68	3·3556	5·1984	103
e	11 59·61	57·6308	162·0107	4
f	11 60·11	6·2124	3·7048	83

The sum of weights is 4092

The result for the Longitude of Liverpool Observatory West of the Royal Observatory, Greenwich ..... $11^m\ 59^s\cdot886$

The probable error of this determination, as depending on the travelling chronometers .. $\pm 0^s\cdot0102$

It will be remembered that this determination is based upon Greenwich transits observed by Mr. Henry, and Liverpool transits observed by Mr. Hartnup, and that no correction is yet applied for Personal Equation.

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X. — *Comparisons and Calculations for the Longitude of Liverpool, as determined with reference to Kingstown.*

THE comparisons at Kingstown were made at nearly the same hour on each of the five days on which comparisons were made, leaving an interval of very nearly forty-eight hours between one comparison and another. The comparisons at Liverpool were made at nearly the same hour on three of the four days on which comparisons were made there, that on the remaining day being nearly six hours later. These circumstances were represented nearly enough by the following assumptions:—

	h
First Interval	18
Second	30
Third	18
Fourth	30
Fifth	24
Sixth	24
Seventh	18
Eighth	30

Using the same notation as in Section VIII., we obtain the following equations:—

$$3x_1 + 5x_2 = 8a_1, \text{ or } x_2 = \frac{8}{5}a_1 - \frac{3}{5}x_1$$

$$5x_2 + 3x_3 = 8b_2, \text{ or } x_3 = \frac{8}{3}b_2 - \frac{5}{3}x_2 = \frac{8}{3}b_2 - \frac{8}{3}a_1 + x$$

$$3x_3 + 5x_4 = 8a_3, \text{ or } x_4 = \frac{8}{5}a_3 - \frac{3}{5}x_3 = \frac{8}{5}a_3 - \frac{8}{5}b_2 + \frac{8}{5}a_1 - \frac{3}{5}x_1$$

$$5x_4 + 4x_5 = 9b_4, \text{ or } x_5 = \frac{9}{4}b_4 - \frac{5}{4}x_4 = \frac{9}{4}b_4 - \frac{8}{4}a_3 + \frac{8}{4}b_2 - \frac{8}{4}a_1 + \frac{3}{4}x_1$$

$$4x_5 + 4x_6 = 8a_5, \text{ or } x_6 = 2a_5 - x_5 = \frac{8}{4}a_5 - \frac{9}{4}b_4 + \frac{8}{4}a_3 - \frac{8}{4}b_2 + \frac{8}{4}a_1 - \frac{3}{4}x_1$$

$$4x_6 + 3x_7 = 7b_6, \text{ or } x_7 = \frac{7}{3}b_6 - \frac{4}{3}x_6 = \frac{7}{3}b_6 - \frac{8}{3}a_5 + \frac{9}{3}b - \frac{8}{3}a_3 + \frac{8}{3}b_2 - \frac{8}{3}a_1 + x_1$$

$$3x_7 + 5x_8 = 8a_7, \text{ or } x_8 = \frac{8}{5}a_7 - \frac{3}{5}x_7 = \frac{8}{5}a_7 - \frac{7}{5}b_6 + \frac{8}{5}a_5 - \frac{9}{5}b_4 + \frac{8}{5}a_3 - \frac{8}{5}b_2 + \frac{8}{5}a_1 - \frac{3}{5}x_1$$

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Hence,

$$x_1 - x_2 = \frac{8}{5}x_1 - \frac{8}{5}a_1$$

$$x_3 - x_2 = \frac{8}{5}x_1 - \frac{64}{15}a_1 + \frac{8}{3}b_2$$

$$x_3 - x_4 = \frac{8}{5}x_1 - \frac{64}{15}a_1 + \frac{64}{15}b_2 - \frac{8}{5}a_3$$

$$x_5 - x_4 = \frac{27}{20}x_1 - \frac{72}{20}a_1 + \frac{72}{20}b_2 - \frac{72}{20}a_3 + \frac{9}{4}b_4$$

$$x_5 - x_6 = \frac{3}{2}x_1 - 4a_1 + 4b_2 - 4a_3 + \frac{9}{2}b_4 - 2a_5$$

$$x - x_6 = \frac{7}{4}x_1 - \frac{56}{12}a_1 + \frac{56}{12}b_2 - \frac{56}{12}a_3 + \frac{63}{12}b_4 - \frac{56}{12}a_5 + \frac{7}{3}b_6$$

$$x_7 - x_8 = \frac{8}{5}x_1 - \frac{64}{15}a_1 + \frac{64}{15}b_2 - \frac{64}{15}a_3 + \frac{72}{15}b_4 - \frac{64}{15}a_5 + \frac{56}{15}b_6 - \frac{8}{5}a_7$$

In order to form the equation which makes the sum of squares of these quantities minimum, each equation ought to be multiplied by the co-efficient of x_1 before taking their sum. But as these co-efficients do not differ much, I have thought it sufficient to take the sum of the equations as they stand. This gives,

$$0 = 11x_1 - \frac{80}{3}a_1 + \frac{352}{15}b_2 - \frac{272}{15}a_3 + \frac{252}{15}b_4 - \frac{164}{15}a_5 + \frac{91}{15}b_6 - \frac{8}{5}a_7$$

Or,

$$x_1 = \frac{1}{165}\left\{400 \cdot a_1 - 352 \cdot b_2 + 272 \cdot a_3 - 252 \cdot b_4 + 164 \cdot a_5 - 91 \cdot b_6 + 24 \cdot a_7\right\}$$

from which x_2, x_3, &c., are found by the equations above.

Then forming the sum of squares of the differences $x_1 - x_2$, $x_3 - x_2$, &c., the probable value of a change of rate will be

$$\frac{\pm 0{\cdot}6745}{7} \times \sqrt{\text{sum of squares.}}$$

The weight W has been made $= \frac{1000}{\text{sum of squares}}$, so that the probable value of a change of rate

$$= \frac{\pm 0{\cdot}6745 \times \sqrt{1000}}{7} \times \frac{1}{\sqrt{W}}.$$

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The probable error of the first rate is $\frac{1}{4}$ of this quantity; and the time through which it applies is $\frac{1}{4}$ of a day: therefore, the probable error of the result of one chronometer for longitude is

$$\pm \frac{15}{32} \times \frac{0{\cdot}6745 \times \sqrt{1000}}{7} \times \frac{1}{\sqrt{W}}.$$

And from this, as before, it is found that the probable error of the result derived from all the chronometers, combining their results in the proportion of the weights, W_A, W_B, W_C, &c., is

$$\pm \frac{15}{32} \times \frac{0{\cdot}6745 \times \sqrt{1000}}{7} \times \frac{1}{\sqrt{(W_A + W_B + \&c.)}}.$$

It will be remarked, that there are in this process some slight inaccuracies; not only because the mathematical theory is not strictly followed, but also because the rate while stationary and the rate while travelling are united in one mixed rate. But I conceive the effect of these to be insignificant.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer A.

Comparisons at Kingstown.				Comparisons at Liverpool.				
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	11 56 2·5	3 35 33·6	−23 43·15							
				+1·90						+2·21
27 21					19 54 25·6	−23 41·82	4 6 42	12 31·78		
				+1·90					+1·57	+1·72
29 3	11 40 30·5	3 12 12·0	−23 39·37						+1·57	
				+1·23						+1·33
29 20					19 37 48·4	−23 38·50	3 57 56	12 31·59		
				+1·23					+1·42	+1·17
31 3	11 53 37·0	3 17 24·4	−23 36·90							
				+1·52					+1·42	+1·73
Aug. 1 3					1 27 16·8	−23 35·47	9 56 15	12 31·76		
				+1·52					+1·07	+1·31
2 3	11 56 45·0	3 12 39·6	−23 33·87						+1·07	
				+1·18						+0·75
2 20					19 18 38·0	−23 33·06	3 54 28	12 31·23		
				+1·18						+1·44
4 3	11 45 31·0	2 53 35·2	−23 31·52							

Concluded Longitude of Liverpool from Kingstown = $12^m\ 31^s{\cdot}55$ East.

Chronometer B.

July 27 3	11 57 10·0	3 29 2·8	−16 5·03							
				+4·00						+4·73
27 21					19 50 12·4	−16 2·25	4 10 9	12 31·84		
				+4·00					+4·16	+3·56
29 3	11 41 55·0	3 5 54·0	−15 57·10						+4·16	
				+4·30						+5·15
29 20					19 32 31·2	−15 54·10	4 0 24	12 31·99		
				+4·30					+4·04	+3·79
31 3	11 54 46·0	3 10 44·8	−15 48·48							
				+5·25					+4·04	+4·36
Aug. 1 3					1 31 7·2	−15 43·53	10 7 58	12 30·50		
				+5·25					+5·19	+6·15
2 3	11 58 36·0	3 6 34·4	−15 37·97						+5·19	
				+4·34						+3·92
2 20					19 14 17·6	−15 34·98	3 58 6	12 30·95		
				+4·34						+4·59
4 3	11 46 43·0	2 46 44·8	−15 29·32							

Concluded Longitude of Liverpool from Kingstown = $12^m\ 31^s{\cdot}34$.

Chronometer C.

July 27 3	11 59 19·0	3 34 29·6	−19 23·18							
				+2·37						+2·69
27 21					19 58 36·0	−19 21·53	4 15 14	12 31·69		
				+2·37					+2·86	+2·18
29 3	11 43 3·0	3 10 23·2	−19 18·49						+2·86	
				+3·38						+4·00
29 20					19 39 37·6	−19 16·11	4 4 9	12 31·98		
				+3·38					+3·00	+3·01
31 3	11 56 7·0	3 15 28·8	−19 11·71							
				+2·73					+3·00	+2·99
Aug. 1 3					1 37 42·0	−19 9·13	10 11 9	12 31·78		
				+2·73					+1·89	+2·47
2 3	11 59 9·0	3 10 35·6	−19 6·26						+1·89	
				+2·64						+1·11
2 20					19 20 33·2	−19 4·44	4 0 52	12 30·38		
				+2·64						+3·56
4 3	11 47 49·5	2 51 22·8	−19 1·00							

Concluded Longitude of Liverpool from Kingstown = $12^m\ 31^s{\cdot}49$.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer D.

Comparisons at Kingstown.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 1 1·0	3 38 34·8	−21 46·67							
				+3·28						+4·36
27 21					20 4 28·0	−21 44·38	4 18 45	12 32·98		
				+3·28					+2·77	+2·63
29 3	11 44 15·5	3 13 57·2	−21 40·18							
				+2·88					+2·77	+3·00
29 20					19 44 12·0	−21 38·15	4 6 22	12 32·27		
				+2·88					+2·74	+2·81
31 3	11 57 20·5	3 19 4·8	−21 34·40							
				+2·38					+2·74	+2·66
Aug. 1 3					1 43 30·8	−21 32·13	10 14 36	12 32·42		
				+2·38					+1·54	+2·10
2 3	12 0 13·0	3 14 2·8	−21 29·63							
				+1·67					+1·54	+0·79
2 20					19 26 23·6	−21 28·48	4 4 20	12 31·45		
				+1·67						+2·20
4 3	11 49 12·0	2 55 10·4	−21 26·31							

Concluded Longitude of Liverpool from Kingstown = 12m 32s·20.

Chronometer E.

July 27 3	12 1 30·0	3 42 0·8	−24 43·75							
				−1·20						−0·33
27 21					20 10 26·4	−24 44·60	4 21 43	12 32·31		
				−1·20					−1·03	−1·72
29 3	11 45 45·0	3 18 32·4	−24 46·13							
				−0·90					−1·03	+0·13
29 20					19 50 12·0	−24 46·77	4 9 14	12 32·42		
				−0·90					−1·33	−1·52
31 3	11 58 46·0	3 23 43·6	−24 47·94							
				−0·22					−1·33	−1·10
Aug. 1 3					1 49 32·0	−24 48·15	10 17 20	12 30·80		
				−0·22					−0·36	+0·66
2 3	12 1 38·5	3 18 46·8	−24 48·37							
				−0·99					−0·36	−1·72
2 20					19 31 47·2	−24 49·05	4 6 23	12 31·08		
				−0·99						−0·55
4 3	11 51 9·5	3 0 31·6	−24 50·34							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·65.

Chronometer F.

July 27 3	12 2 56·5	3 41 12·4	−22 29·06							
				−0·12						+0·57
27 21					20 10 59·6	−22 29·14	4 24 32	12 32·19		
				−0·12					−0·14	−0·53
29 3	11 46 44·0	3 17 14·4	−22 29·29							
				+0·11					−0·14	+0·52
29 20					19 50 48·4	−22 29·21	4 12 8	12 31·99		
				+0·11					+0·33	−0·13
31 3	12 0 11·5	3 22 50·0	−22 29·06							
				+1·14					+0·33	+0·91
Aug. 1 3					1 52 51·2	−22 27·97	10 23 1	12 31·49		
				+1·14					+0·46	+1·37
2 3	12 3 32·0	3 18 18·4	−22 26·78							
				+0·03					+0·46	−0·75
2 20					19 32 36·4	−22 26·76	4 9 35	12 31·08		
				+0·03						+0·50
4 3	12 0 49·5	3 7 46·4	−22 26·72							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·69.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer G.

Comparisons at Kingstown.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 4 11·5	3 42 8·8	−22 10·67							
				+3·53						+3·41
27 21					20 12 55·2	−22 8·19	4 26 48	12 31·27		
				+3·53					+3·60	+3·60
29 3	11 47 51·0	3 17 55·6	−22 3·68							
				+3·10					+3·60	+3·60
29 20					19 53 40·4	−22 1·49	4 15 28	12 31·72		
				+3·10					+2·83	+2·80
31 3	12 1 18·5	3 23 25·2	−21 57·45							
				+2·77					+2·83	+2·87
Aug. 1 3					1 56 34·4	−21 54·81	10 27 18	12 31·43		
				+2·77					+2·56	+2·67
2 3	12 4 21·0	3 18 32·4	−21 51·91							
				+2·80					+2·56	+2·41
2 20					19 36 2·0	−21 49·97	4 13 38	12 31·03		
				+2·80						+3·03
4 3	12 2 4·5	3 8 20·8	−21 46·32							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·34.

Chronometer H.

July 27 3	12 5 31·0	3 33 41·6	−12 24·19							
				+6·10						+6·52
27 21					20 5 32·0	−12 19·94	4 29 14	12 31·82		
				+6·10					+6·25	+5·85
29 3	11 50 31·0	3 10 43·6	−12 12·10							
				+5·69					+6·25	+6·92
29 20					19 46 48·8	−12 8·10	4 18 31	12 32·44		
				+5·69					+5·18	+4·95
31 3	12 3 56·5	3 16 6·0	−12 0·68							
				+5·90					+5·18	+5·47
Aug. 1 3					1 49 52·4	−11 55·06	10 30 36	12 31·14		
				+5·90					+5·76	+6·34
2 3	12 5 23·0	3 9 31·2	−11 48·87							
				+6·24					+5·76	+4·99
2 20					19 29 30·4	−11 44·57	4 17 12	12 30·64		
				+6·24						+6·99
4 3	12 3 45·5	2 59 51·6	−11 36·40							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·55.

Chronometer I.

July 27 3	12 11 11·0	3 50 0·4	−23 3·91							
				+1·58						+2·42
27 21					20 24 49·2	−23 2·79	4 37 50	12 32·07		
				+1·58					+1·23	+1·08
29 3	11 51 28·5	3 22 29·6	−23 0·76							
				+0·32					+1·23	+1·49
29 20					20 0 12·0	−23 0·53	4 21 2	12 32·26		
				+0·32					+0·05	−0·38
31 3	12 5 22·5	3 28 31·2	−23 0·11							
				+1·07					+0·05	+0·59
Aug. 1 3					2 3 39·2	−22 59·09	10 33 19	12 30·93		
				+1·07					+0·67	+1·55
2 3	12 6 38·5	3 21 55·6	−22 57·98							
				+0·44					+0·67	−0·51
2 20					19 44 48·8	−22 57·68	4 21 18	12 30·69		
				+0·44						+1·01
4 3	12 4 24·5	3 11 51·2	−22 57·11							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·42.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer J.

Comparisons at Kingstown.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 12 26·0	3 51 25·6	−23 14·32							
				+2·20						+2·48
27 21					20 29 54·0	−23 12·75	4 42 45	12 31·42		
				+2·20					+2·74	+2·03
29 3	11 52 41·5	3 23 51·6	−23 9·95							
				+2·87					+2·74	+3·92
29 20					20 4 6·0	−23 7·91	4 24 49	12 32·02		
				+2·87					+2·46	+2·24
31 3	12 6 27·0	3 29 39·6	−23 4·18							
				+3·39					+2·46	+2·74
Aug. 1 3					2 5 58·0	−23 0·94	10 35 36	12 30·60		
				+3·39					+3·15	+4·05
2 3	12 8 43·0	3 23 59·2	−22 57·42							
				+2·66					+3·15	+1·96
2 20					19 47 47·2	−22 55·56	4 24 19	12 30·68		
				+2·66						+3·08
4 3	12 5 42·5	3 13 4·0	−22 52·12							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·22.

Chronometer K.

July										
27 3	12 13 52·5	3 55 11·2	−25 33·66							
				−0·12						−0·28
27 21					20 37 13·2	−25 33·74	4 47 44	12 31·40		
				−0·12					0·00	−0·02
29 3	11 55 54·5	3 29 28·0	−25 33·89							
				−0·02					0·00	+0·04
29 20					20 10 32·8	−25 33·90	4 28 50	12 31·56		
				−0·02					+0·50	−0·06
31 3	12 7 57·5	3 33 39·6	−25 33·93							
				+0·75					+0·50	+1·20
Aug. 1 3					2 16 19·6	−25 33·20	10 43 28	12 31·99		
				+0·75					−0·05	+0·31
2 3	12 9 59·0	3 27 50·0	−25 32·42							
				+0·26					−0·05	−0·52
2 20					19 52 55·2	−25 32·24	4 26 51	12 30·94		
				+0·26						+0·73
4 3	12 6 50·5	3 16 51·6	−25 31·90							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·53.

Chronometer K*.

July										
27 3	12 15 35·5	3 54 1·0	−22 40·74							
				+3·73						+3·23
27 21					20 43 3·8	−22 38·07	4 56 32	12 31·70		
				+3·73					+5·28	+4·03
29 3	11 56 59·0	3 27 31·8	−22 33·36							
				+6·37					+5·28	+7·37
29 20					20 9 47·0	−22 28·82	4 31 11	12 32·90		
				+6·37					+5·45	+5·77
31 3	12 9 20·5	3 31 49·0	−22 20·56							
				+5·45					+5·45	+5·05
Aug. 1 3					2 15 18·6	−22 15·30	10 45 45	12 31·71		
				+5·45					+5·17	+5·86
2 3	12 11 25·0	3 25 53·0	−22 9·65							
				+4·88					+5·17	+4·26
2 20					19 51 40·2	−22 6·23	4 29 3	12 31·59		
				+4·88						+5·25
4 3	12 9 19·5	3 15 48·2	−21 59·91							

Concluded Longitude of Liverpool from Kingstown = 12m 32s·09.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer M.

Comparisons at Kingstown.				Comparisons at Liverpool.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 17 45·5	3 57 33·2	−24 3·29							
				+0·16						+0·86
27 21					20 49 2·8	−24 3·17	5 1 7	12 32·06		
				+0·16					−0·21	−0·26
29 3	12 1 56·0	3 33 57·6	−24 2·97							
				+0·07					−0·21	−0·13
29 20					20 13 51·2	−24 2·92	4 33 40	12 31·39		
				+0·07					−0·28	+0·19
31 3	12 11 38·0	3 35 48·4	−24 2·83							
				−1·21					−0·28	−0·87
Aug. 1 3					2 26 47·6	−24 3·99	10 55 27	12 31·83		
				−1·21					−1·41	−1·56
2 3	12 13 44·0	3 30 7·2	−24 5·24							
				−0·65					−1·41	−1·22
2 20					19 55 50·8	−24 5·69	4 31 14	12 31·09		
				−0·65						−0·31
4 3	12 10 4·0	3 18 39·2	−24 6·53							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·53.

Chronometer N.

July 27 3	12 18 55·5	3 58 5·2	−23 25·48							
				+0·46						+0·27
27 21					20 52 31·6	−23 25·15	5 5 14	12 31·56		
				+0·46					+0·12	+0·57
29 3	12 6 56·0	3 38 18·4	−23 24·57							
				−0·05					+0·12	−0·64
29 20					20 15 49·6	−23 24·61	4 36 17	12 31·25		
				−0·05					+0·82	+0·30
31 3	12 13 6·0	3 36 38·0	−23 24·67							
				+0·71					+0·82	+1·47
Aug. 1 3					2 34 17·6	−23 23·98	11 3 39	12 32·49		
				+0·71					+0·06	−0·05
2 3	12 16 14·0	3 31 54·8	−23 23·24							
				+0·51					+0·06	+0·20
2 20					19 57 23·2	−23 22·89	4 33 30	12 31·51		
				+0·51						+0·69
4 3	12 11 20·5	3 19 11·2	−23 22·23							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·71.

Chronometer O.

July 27 3	12 20 46·0	3 47 52·0	−11 22·08							
				+1·17						+1·39
27 21					20 44 48·8	−11 21·25	5 9 36	12 31·74		
				+1·17					+1·64	+1·04
29 3	12 8 35·5	3 27 52·8	−11 19·76							
				+1·77					+1·64	+2·64
29 20					20 6 52·0	−11 18·52	4 39 27	12 32·25		
				+1·77					+1·53	+1·25
31 3	12 14 37·5	3 26 0·8	−11 16·22							
				+2·80					+1·53	+1·89
Aug. 1 3					2 25 16·4	−11 13·52	11 6 47	12 30·72		
				+2·80					+3·12	+3·72
2 3	12 17 22·0	3 20 50·0	−11 10·64							
				+2·82					+3·12	+2·33
2 20					19 47 52·8	−11 8·69	4 36 14	12 31·27		
				+2·82						+3·12
4 3	12 12 29·5	3 8 2·8	−11 5·02							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·60.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer P.

Approximate Solar Time, 1844.	Comparisons at Kingstown: Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Liverpool: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 24 5·0	4 12 55·2	−33 6·81							
				−5·43						−4·65
27 21					21 24 16·0	−33 10·82	5 27 17	12 32·23		
				−5·43					−6·10	−5·90
29 3	12 10 44·0	3 51 58·8	−33 17·60							
				−6·54					−6·10	−6·43
29 20					20 55 46·0	−33 22·40	5 6 21	12 31·74		
				−6·54					−6·13	−6·60
31 3	12 18 4·0	3 51 41·2	−33 30·68							
				−5·68					−6·13	−5·54
Aug. 1 3					3 47 5·6	−33 36·48	12 6 24	12 31·77		
				−5·68					−6·10	−5·82
2 3	12 19 45·0	3 45 44·0	−33 42·02							
				−5·47					−6·10	−6·47
2 20					20 41 32·4	−33 46·02	5 7 21	12 30·92		
				−5·47						−4·87
4 3	12 19 58·0	3 38 18·0	−33 52·95							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·64.

Chronometer Q.

July 27 3	12 25 22·0	4 3 22·4	−22 17·22							
				+3·46						+3·07
27 21					21 18 58·4	−22 14·68	5 32 55	12 30·77		
				+3·46					+3·22	+3·70
29 3	12 12 19·5	3 42 26·8	−22 10·36							
				+1·99					+3·22	+2·43
29 20					20 49 56·0	−22 8·91	5 11 45	12 31·37		
				+1·99					+1·61	+1·73
31 3	12 19 53·0	3 42 5·6	−22 6·38							
				+0·78					+1·61	+1·46
Aug. 1 3					3 37 48·4	−22 5·59	12 8 38	12 31·72		
				+0·78					+0·28	+0·10
2 3	12 20 54·0	33 5 15·62	−22 4·82							
				+0·73					+0·28	+0·52
2 20					20 38 59·2	−22 4·29	5 16 31	12 30·90		
				+0·73						+0·85
4 3	12 21 53·5	3 28 23·6	−22 3·36							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·05.

Chronometer R.

July 27 3	12 26 25·0	4 9 58·8	−27 50·79							
				−1·80						−1·14
27 21					21 33 4·8	−27 52·13	5 41 27	12 32·43		
				−1·80					−2·65	−2·20
29 3	12 13 34·5	3 49 25·6	−27 54·37							
				−2·70					−2·65	−3·41
29 20					20 59 22·8	−27 56·35	5 15 25	12 31·42		
				−2·70					−1·90	−2·28
31 3	12 21 3·0	3 49 8·8	−27 59·77							
				−1·73					−1·90	−1·43
Aug. 1 3					3 45 56·4	−28 1·52	12 10 51	12 32·29		
				−1·73					−2·03	−2·03
2 3	12 23 32·0	3 43 51·6	−28 3·22							
				−1·92					−2·03	−2·03
2 20					20 48 10·0	−28 4·63	5 19 43	12 31·93		
				−1·92						−1·85
4 3	12 23 6·0	3 35 39·6	−28 7·05							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·98.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer S.

Comparisons at Kingstown.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 27 56·5	4 2 37·6	−18 58·34							
				+2·59						+3·01
27 21					21 32 7·6	−18 56·41	5 49 26	12 31·61		
				+2·59					+2·29	+2·34
29 3	12 15 36·0	3 42 25·6	−18 53·20						+2·29	
				+3·19						+2·21
29 20					20 53 35·6	−18 50·87	5 18 43	12 30·59		
				+3·19					+4·85	+3·78
31 3	12 22 37·0	3 41 29·6	−18 46·82							
				+6·24					+4·85	+6·19
Aug. 1 3					3 41 9·6	−18 40·48	12 15 25	12 31·30		
				+6·24					+5·28	+6·29
2 3	12 24 55·5	3 35 46·0	−18 34·35							
				+3·26					+5·28	+3·93
2 20					20 45 2·4	−18 31·97	5 26 9	12 31·82		
				+3·26						+2·86
4 3	12 26 10·5	3 29 4·4	−18 27·85							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·33.

Chronometer T.

July 27 3	12 29 4·5	4 8 15·2	−23 28·13							
				+1·33						+1·85
27 21					21 41 37·2	−23 27·13	5 54 26	12 31·92		
				+1·33					+0·86	+1·02
29 3	12 16 39·5	3 48 1·2	−23 25·48						+0·86	
				+0·54						+0·60
29 20					21 0 54·4	−23 25·08	5 21 29	12 31·56		
				+0·54					+0·20	+0·51
31 3	12 24 55·0	3 48 24·8	−23 24·39							
				−0·34					+0·20	−0·18
Aug. 1 3					3 48 52·0	−23 24·74	12 18 24	12 31·68		
				−0·34					−0·55	−0·50
2 3	12 26 15·0	3 41 56·0	−23 25·07							
				−0·61					−0·55	−0·62
2 20					20 52 48·8	−23 25·51	5 29 2	12 31·50		
				−0·61						−0·60
4 3	12 27 31·5	3 35 23·6	−23 26·28							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·52.

Chronometer U.

July 27 3	12 30 24·5	4 6 37·6	−20 30·74							
				+5·57						+5·20
27 21					21 41 52·0	−20 26·57	5 57 41	12 31·02		
				+5·57					+5·70	+5·79
29 3	12 17 45·5	3 46 1·2	−20 19·66						+5·70	
				+5·72						+5·55
29 20					21 2 14·4	−20 15·48	5 25 59	12 31·22		
				+5·72					+6·30	+5·82
31 3	12 25 44·5	3 45 58·0	−20 8·22							
				+6·49					+6·30	+6·89
Aug. 1 3					3 49 13·2	−20 1·63	12 22 9	12 31·76		
				+6·49					+5·58	+6·09
2 3	12 27 23·0	3 39 34·0	−19 55·25							
				+4·64					+5·58	+4·91
2 20					20 51 12·8	−19 51·85	5 31 0	12 31·51		
				+4·64						+4·48
4 3	12 29 59·0	3 34 10·4	−19 45·98							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·33.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer W.

Approximate Solar Time, 1844.	Comparisons at Kingstown. Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Liverpool. Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 31 35·5	4 21 30·2	−34 12·53							
				−8·18						−8·23
27 21					22 2 1·4	−34 18·73	6 4 0	12 31·75		
				−8·18					−7·72	−8·15
29 3	12 19 54·5	4 2 19·0	−34 28·81							
				−8·15					−7·72	−7·00
29 20					21 19 49·8	−34 34·87	5 29 17	12 32·68		
				−8·15					−8·19	−8·84
31 3	12 26 52·0	4 1 42·2	−34 45·11							
				−7·52					−8·19	−7·38
Aug. 1 3					4 6 31·8	−34 52·82	12 24 37	12 31·94		
				−7·52					−8·63	−7·66
2 3	12 28 28·5	3 55 44·2	−35 0·13							
				−8·44					−8·63	−9·92
2 20					21 14 31·8	−35 6·44	5 39 5	12 30·78		
				−8·44						−7·55
4 3	12 30 45·5	3 50 27·8	−35 17·00							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·81.

Chronometer X.

July 27 3	12 32 46·0	4 13 26·2	−24 58·23							
				−0·76						−0·92
27 21					22 4 27·8	−24 58·81	6 15 48	12 31·51		
				−0·76					−0·64	−0·67
29 3	12 22 1·5	3 54 56·6	−24 59·74							
				−0·98					−0·64	−0·60
29 20					21 17 21·0	−25 0·47	5 36 23	12 31·92		
				−0·98					−0·82	−1·21
31 3	12 28 8·0	3 53 14·6	−25 1·71							
				−0·26					−0·82	−0·33
Aug. 1 3					4 3 50·2	−25 1·97	12 31 47	12 31·53		
				−0·26					−0·49	−0·19
2 3	12 29 37·0	3 46 54·6	−25 2·22							
				−0·63					−0·49	−0·89
2 20					21 7 3·0	−25 2·68	5 41 41	12 31·40		
				−0·63						−0·47
4 3	12 31 48·0	3 41 16·6	−25 3·47							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·62.

Chronometer Y.

July 27 3	12 34 36·5	4 11 12·6	−20 54·42							
				+3·87						+4·18
27 21					22 4 7·0	−20 51·49	6 19 35	12 31·38		
				+3·87					+3·23	+3·69
29 3	12 23 17·5	3 51 59·4	−20 46·74							
				+3·06					+3·23	+2·47
29 20					21 15 35·8	−20 44·46	5 38 53	12 30·70		
				+3·06					+3·74	+3·41
31 3	12 29 22·5	3 50 7·8	−20 40·61							
				+3·65					+3·74	+4·15
Aug. 1 3					4 4 6·2	−20 36·86	12 36 29	12 31·66		
				+3·65					+3·16	+3·15
2 3	12 31 27·0	3 44 15·4	−20 33·32							
				+3·21					+3·16	+3·17
2 20					21 4 28·2	−20 30·94	5 43 38	12 31·14		
				+3·21						+3·23
4 3	12 33 18·0	3 38 9·8	−20 26·91							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·17.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer Z.

Approximate Solar Time, 1844.	Comparisons at Kingstown. Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Liverpool. Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 35 55·0	4 13 32·2	−21 55·74							
				+2·08						+1·71
27 21					22 8 15·0	−21 54·16	6 22 41	12 31·53		
				+2·08					+2·60	+2·30
29 3	12 24 22·0	3 54 8·6	−21 51·61							
				+1·90					+2·60	+3·10
29 20					21 19 0·2	−21 50·20	5 41 14	12 32·67		
				+1·90					+1·55	+1·18
31 3	12 30 35·5	3 52 27·8	−21 47·81							
				+2·05					+1·55	+2·01
Aug. 1 3					4 7 30·6	−21 45·71	12 38 45	12 31·74		
				+2·05					+1·27	+2·09
2 3	12 34 31·5	3 48 29·8	−21 43·72							
				+0·80					+1·27	+0·18
2 20					21 10 29·4	−21 43·13	5 48 28	12 31·33		
				+0·80						+1·17
4 3	12 34 33·0	3 40 39·8	−21 42·12							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·79.

Chronometer *a*.

Approximate Solar Time, 1844.	Comparisons at Kingstown. Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Liverpool. Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 39 18·0	4 20 28·2	−25 29·28							
				−0·51						−0·78
27 21					22 19 33·0	−25 29·67	6 30 24	12 30·79		
				−0·51					−0·42	−0·35
29 3	12 25 29·5	3 58 54·6	−25 30·30							
				−0·35					−0·42	−0·54
29 20					21 26 9·8	−25 30·56	5 44 42	12 30·85		
				−0·35					−0·11	−0·24
31 3	12 31 42·5	3 57 17·8	−25 30·99							
				−0·25					−0·11	+0·05
Aug. 1 3					4 13 40·2	−25 31·24	12 41 9	12 31·27		
				−0·25					−0·48	−0·55
2 3	12 36 46·5	3 54 32·2	−25 31·48							
				−0·32					−0·48	−0·39
2 20					21 16 45·0	−25 31·72	5 50 55	12 30·93		
				−0·32						−0·28
4 3	12 35 48·0	3 45 44·6	−25 32·12							

Concluded Longitude of Liverpool from Kingstown = 12m 30s·99.

Chronometer *b*.

Approximate Solar Time, 1844.	Comparisons at Kingstown. Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Liverpool. Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 41 15·5	4 19 44·2	−22 48·10							
				+2·09						+2·16
27 21					22 20 5·8	−22 46·50	6 33 41	12 31·29		
				+2·09					+2·08	+2·05
29 3	12 26 54·5	3 57 33·0	−22 43·94							
				+1·43					+2·08	+2·13
29 20					21 24 39·0	−22 42·90	5 46 0	12 31·79		
				+1·43					+1·21	+1·01
31 3	12 32 53·0	3 55 38·2	−22 41·09							
				+1·50					+1·21	+1·46
Aug. 1 3					4 13 0·2	−22 39·55	12 43 21	12 31·22		
				+1·50					+1·35	+1·54
2 3	12 38 6·5	3 52 58·6	−22 38·10							
				+1·88					+1·35	+1·10
2 20					21 16 23·8	−22 36·70	5 53 29	12 30·69		
				+1·88						+2·35
4 3	12 37 42·5	3 44 41·0	−22 34·34							

Concluded Longitude of Liverpool from Kingstown = 12m 31s·26.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF LIVERPOOL FROM KINGSTOWN.

Chronometer *d.*

Comparisons at Kingstown.					Comparisons at Liverpool.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Liverpool Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3	12 42 46·5	4 18 6·37	−19 39·53							
				+4·55						+5·57
27 21					23 54 1·5	−19 35·75	8 11 5	12 32·96		
				+4·55					+3·91	+3·94
29 3	12 28 8·5	3 55 33·36	−19 30·50							
				+2·97					+3·91	+3·86
29 20					21 53 3·0	−19 28·23	6 17 45	12 32·94		
				+2·97					+2·73	+2·44
31 3	12 36 57·5	3 56 25·5	−19 24·54							
				+3·53					+2·73	+3·10
Aug. 1 3					4 21 53·0	−19 20·89	12 55 35	12 31·77		
				+3·53					+3·24	+3·96
2 3	12 40 21·0	3 51 52·13	−19 17·49							
				+2·96					+3·24	+2·28
2 20					21 18 35·5	−19 15·29	5 59 4	12 31·69		
				+2·96						+3·37
4 3	12 39 15·5	3 42 51·0	−19 11·58							

Concluded Longitude of Liverpool from Kingstown = $12^m\ 32^s{\cdot}21$.

Chronometer *e.*

July										
27 3	12 45 0·0	4 24 30·0	−23 50·01							
				−0·11						+0·45
27 21					24 6 36·0	−23 50·10	8 19 25	12 31·45		
				−0·11					−0·52	−0·44
29 3	12 30 10·5	4 1 54·75	−23 50·22							
				−1·33					−0·52	−0·65
29 20					22 8 52·5	−23 51·24	6 29 12	12 31·59		
				−1·33					−1·29	−1·74
31 3	12 39 46·5	4 3 42·38	−23 52·88							
				−1·34					−1·29	−0·73
Aug. 1 3					4 32 25·5	−23 54·26	13 1 35	12 31·68		
				−1·34					−2·75	−1·95
2 3	12 41 27·0	3 57 36·0	−23 55·54							
				−2·46					−2·75	−3·81
2 20					21 30 15·0	−23 57·38	6 6 1	12 30·12		
				−2·46						−1·65
4 3	12 40 46·0	3 49 10·13	−24 0·46							

Concluded Longitude of Liverpool from Kingstown = $12^m\ 31^s{\cdot}06$.

Chronometer *f.*

July										
27 3	12 47 12·5	4 30 18·38	−27 26·26							
				−2·88						−2·66
27 21					24 28 49·5	−27 28·71	8 38 3	12 31·53		
				−2·88					−2·85	−3·01
29 3	12 31 44·0	4 7 9·75	−27 31·97							
				−2·81					−2·85	−2·58
29 20					22 18 34·5	−27 34·15	6 35 12	12 31·52		
				−2·81					−2·93	−2·95
31 3	12 40 22·5	4 8 3·0	−27 37·60							
				−3·10					−2·93	−2·91
Aug. 1 3					4 40 23·5	−27 40·81	13 5 47	12 31·53		
				−3·10					−3·53	−3·29
2 3	12 44 28·0	4 4 24·75	−27 43·79							
				−3·20					−3·53	−3·85
2 20					21 52 48·0	−27 46·23	6 24 49	12 30·91		
				−3·20						−2·81
4 3	12 42 52·5	3 55 6·0	−27 50·18							

Concluded Longitude of Liverpool from Kingstown = $12^m\ 31^s{\cdot}36$.

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The following Table contains the Results from all the Chronometers.

Reference to Chronometer.	Longitude of Liverpool East of Kingstown.	Sum of Squares of Changes of Rates.	Weight of Result.
	m s		
A	12 31·55	1·6975	589
B	12 31·34	14·6974	68
C	12 31·49	12·6755	79
D	12 32·20	7·2062	139
E	12 31·65	18·3844	54
F	12 31·69	10·0851	99
G	12 31·34	1·1730	852
H	12 31·55	12·3245	81
I	12 31·42	13·8771	72
J	12 31·22	14·1856	70
K	12 31·53	4·7123	212
*K**	12 32·09	19·0702	52
M	12 31·53	3·9171	255
N	12 31·71	6·4196	156
O	12 31·60	10·9293	91
P	12 31·64	6·0568	165
Q	12 31·05	4·7076	212
R	12 31·98	4·9795	201
S	12 31·33	15·4633	65
T	12 31·52	1·4667	682
U	12 31·33	3·8408	260
W	12 31·81	17·6490	57
X	12 31·62	1·8999	526
Y	12 31·17	4·1637	240
Z	12 31·79	9·9980	100
a	12 30·99	0·7928	1261
b	12 31·26	3·2379	309
d	12 32·21	9·8654	101
e	12 31·06	12·6580	79
f	12 31·36	1·9855	504

The sum of weights is 7631

The result for the Longitude of Liverpool Observatory East of the temporary observatory at Kingstown ..... $12^m\ 31^s\cdot413$

The probable error of this determination, as depending on the unsteadiness of rate of the travelling chronometers ..... $\pm 0^s\cdot0164$

It must be borne in mind that this determination is based upon Kingstown transits as observed by Mr. Hind, and Liverpool transits as observed by Mr. Hartnup, and that no correction is yet applied for Personal Equation.

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XI. — *Comparisons and Calculations for the Longitude of Kingstown, as determined immediately with reference to Greenwich.*

The chronometers on arriving at Greenwich in the evening, were immediately compared with the transit-clock (in every instance except on July $25^d.\ 10^h$); and immediately before leaving Greenwich in the morning they were again compared with the transit-clock. They reached Kingstown the next morning; but at Kingstown they were compared only once (excepting on July 20 and 21, when they were detained a day longer than usual). They left Kingstown in the evening, and arrived at Greenwich the next evening. Thus, in general, a stationary rate was obtained from the comparisons at Greenwich, but none was obtained from those at Kingstown.

For the calculation, it was supposed that the stationary rates were independent of the travelling rates, and that (so far as they were unknown) they might be assumed to follow the same law as that assumed for travelling rates, namely, that the sum of squares of change of rate is minimum. This evidently gave, for every stationary rate at Kingstown, a value equal to the mean of the stationary rates preceding and following it at Greenwich. In the first instance of all, the first Greenwich stationary rate was carried back for use in the first Kingstown stationary interval; and in the last instances of all (the last Greenwich stationary rate having been lost for want of the comparison at July $25^d\ 10^h$), the stationary rate between July $22^d\ 10^h$ and $22^d\ 19^h$ was used for the subsequent rests both at Greenwich and at Kingstown. And the Kingstown stationary rate derived from the Kingstown comparisons at July $20^d\ 9^h$ and $21^d\ 5^h$ was used for the whole Kingstown rest, from July $19^d\ 19^h$ to July $21^d\ 7^h$. In this way the whole of the stationary rates were adopted.

The next point was, to fix upon the intervals which should be used respectively for the stationary rates and for the travelling rates. Upon examining the times of arrival and departure of the chronometers, it appeared that the journey from Greenwich to Kingstown occupied nearly 24 hours,

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while that from Kingstown to Greenwich occupied nearly 27 hours. For convenience, therefore, the following supposition was made. It was assumed that the applicability of the Greenwich stationary rate terminated at the moment of the chronometer's comparison before leaving Greenwich, and that the travelling rate then applied for 24 hours exactly. It was also assumed that the next travelling rate applied for 27 hours exactly before the moment of the chronometer's comparison on arrival at Greenwich. To the space intervening between the end of the 24 hours and the beginning of the 27 hours, the Kingstown stationary rate was supposed to apply.

In the particular case of July $25^d\ 10^h$, when no comparison was made at Greenwich, the adoption of a time for the end of the 27 hours was unimportant, because the same stationary rate was held to apply to the rests at Kingstown and Greenwich which preceded and followed it.

The intervals to which the stationary rates applied being thus adopted, and proportionate parts of the stationary rates for these intervals being taken, and being subtracted from the whole chronometer's loss between two comparisons at the same place, the remainder was the chronometer's loss in 51 hours, from which an apparent travelling rate was obtained. This was then treated on the principles explained in Section VIII., the successive equations being,

$$\begin{aligned} 24\,x_1 + 27\,x_2 &= 51\,a_1 \\ 27\,x_2 + 24\,x_3 &= 51\,b_2 \\ 24\,x_3 + 27\,x_4 &= 51\,a_3, \\ &\text{\&c.}\quad\text{\&c.} \end{aligned}$$

and therefore, if we make

$$\begin{aligned} A_1 &= a_1 \\ A_2 &= -\frac{9}{8}(b_2 - a_1) \\ A_3 &= a_3 - b_2 + a_1 \\ A_4 &= -\frac{9}{8}(b_4 - a_3 + b_2 - a_1) \\ A_5 &= a_5 - b_4 + a_3 - b_2 + a_1 \\ A_6 &= -\frac{9}{8}(b_6 - a_5 + b_4 - a_3 + b_2 - a_1), \\ &\text{\&c.}\quad\text{\&c.} \end{aligned}$$

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we obtain

$$x_1 - x_2 = \frac{17}{9} x_1 - \frac{17}{9} A_1$$

$$x_2 - x_3 = \frac{17}{9} x_1 - \frac{17}{9} (A_2 + A_1)$$

$$x_3 - x_4 = \frac{17}{9} x_1 - \frac{17}{9} (A_3 + A_2)$$

$$x_5 - x_4 = \frac{17}{9} x_1 - \frac{17}{9} (A_4 + A_3)$$

$$x_5 - x_6 = \frac{17}{9} x_1 - \frac{17}{9} (A_5 + A_4),$$

&c. &c.

and making the sum of the squares minimum,

$$(n-1)\, x_1 = 2A_1 + 2A_2 + \text{\&c.}, + A_{n-1},$$

from which x_1 is determined; and x_2, x_3, &c., are immediately found by the first equations.

The probable error of change of rate will be,

$$\frac{\pm\, 0{\cdot}6745}{17} \times \sqrt{\text{minimum sum of squares of changes of rate}}.$$

Now the weight W has been taken,

$$= \frac{1000}{\text{minimum sum of squares of changes of rate}};$$

and hence the probable error of change of rate,

$$= \frac{\pm\, 0{\cdot}6745}{17} \times \sqrt{\frac{1000}{W}}.$$

And the probable error of x_1

$$= \pm \frac{9}{17} \times \frac{0{\cdot}6745}{17} \times \sqrt{\frac{1000}{W}}.$$

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The rate x_1 is used for 24 hours exactly; and hence the probable error of the longitude determined from it is,

$$\pm \frac{9}{17} \times \frac{0{\cdot}6745}{17} \times \sqrt{\frac{1000}{W}}.$$

And from this we deduce, in the same manner as before, that the probable error in the result obtained by combining the results of all the chronometers with the respective weights, W_A, W_B, &c., is

$$\pm \frac{9}{17} \times \frac{0{\cdot}6745}{17} \times \sqrt{\frac{1000}{W_A + W_B + \&c.}}.$$

In explanation of the following tables it is necessary to remark that several comparisons of each chronometer, with the transit clock or with the stationary chronometer ½ Σ at Kingstown, were usually taken at the same time, and that in some instances there was a trifling discordance among them, so that no one could be selected for printing which gave the same result as the mean of all, and then a small addition has sometimes been made in the second place of decimals.

The chronometer L failed before the last double trip; and the sum of squares was increased by ¼ part before its weight was taken.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER A.

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 4 49	18 43 4·4	+0 0·63							
				+1·11						+0·82
27 19									+2·88	
27 22					22 18 4·8	+0 2·31	4 43 12·5	24 31·62		
28 7									+2·88	
				+1·11					+1·60	+1·37
29 10	17 15 23	10 43 6·4	+0 4·54							
				+2·88						
30 19	1 32 12	18 54 35·6	+0 8·40						+1·60	+1·86
July				+1·26						
1 19									+2·34	
2 1					1 22 32·0	+0 10·28	8 4 1·0	24 30·56		
2 7									+2·34	
				+1·26					+1·20	+0·73
3 10	17 15 9	10 27 5·2	+0 12·30							
				+1·79						
3 19	2 8 19	19 18 47·6	+0 12·96						+1·20	+1·73
				+1·58						
4 19									+1·02	
5 2					1 47 28·8	+0 14·85	8 40 52·5	24 31·05		
5 7									+1·02	
				+1·58					+1·15	+1·45
6 10	17 27 3	10 27 8·4	+0 16·85							
				+0·25						
7 19	2 34 45	19 29 26·0	+0 17·19						+1·15	+0·82
				+1·17						
8 19									+1·32	
9 3					3 5 22·4	+0 18·75	10 14 44·0	24 31·50		
9 7									+1·32	
				+1·17					+1·41	+1·48
10 10	17 32 42	10 17 4·0	+0 20·31							
				+2·38						
10 19	2 43 9	19 26 0·4	+0 21·22						+1·41	+1·33
				+1·56						
11 19									+1·41	
12 3					2 57 48·0	+0 23·22	10 18 58·5	24 31·38		
12 7									+1·41	
				+1·56					+1·29	+1·76
13 10	17 42 59	10 15 30·4	+0 25·23							
				+0·43						
14 19	3 3 1	19 30 5·6	+0 25·83						+1·29	+0·76
				+1·04						
15 19									+0·50	
16 4					4 3 20·4	+0 27·10	11 40 27·0	24 31·48		
16 7									+0·50	
				+1·04					+0·96	+1·30
17 10	17 52 57	10 9 44·8	+0 28·28							
				+0·56						
18 19	3 18 4	19 29 24·4	+0 29·06						+0·96	+0·59
				+1·16						
19 19									+1·12	

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The rate x_1 is used for 24 hours exactly; and hence the probable error of the longitude determined from it is,

$$\pm \frac{9}{17} \times \frac{0{\cdot}6745}{17} \times \sqrt{\frac{1000}{W}}.$$

And from this we deduce, in the same manner as before, that the probable error in the result obtained by combining the results of all the chronometers with the respective weights, W_A, W_B, &c., is

$$\pm \frac{9}{17} \times \frac{0{\cdot}6745}{17} \times \sqrt{\frac{1000}{W_A + W_B + \&c.}}.$$

In explanation of the following tables it is necessary to remark that several comparisons of each chronometer, with the transit clock or with the stationary chronometer ½ Σ at Kingstown, were usually taken at the same time, and that in some instances there was a trifling discordance among them, so that no one could be selected for printing which gave the same result as the mean of all, and then a small addition has sometimes been made in the second place of decimals.

The chronometer *L* failed before the last double trip; and the sum of squares was increased by ¼ part before its weight was taken.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER A.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 4 49	18 43 4·4	+0 0·63							
				+1·11						+0·82
27 19									+2·88	
27 22					22 18 4·8	+0 2·31	4 43 12·5	24 31·62	+2·88	
28 7				+1·11					+1·60	+1·37
29 10	17 15 23	10 43 6·4	+0 4·54							
				+2·88						
30 19	1 32 12	18 54 35·6	+0 8·40						+1·60	+1·86
				+1·26						
July 1 19									+2·34	
2 1					1 22 32·0	+0 10·28	8 4 1·0	24 30·56	+2·34	
2 7				+1·26					+1·20	+0·73
3 10	17 15 9	10 27 5·2	+0 12·30							
				+1·79						
3 19	2 8 19	19 18 47·6	+0 12·96						+1·20	+1·73
				+1·58						
4 19									+1·02	
5 2					1 47 28·8	+0 14·85	8 40 52·5	24 31·05	+1·02	
5 7				+1·58					+1·15	+1·45
6 10	17 27 3	10 27 8·4	+0 16·85							
				+0·25						
7 19	2 34 45	19 29 26·0	+0 17·19						+1·15	+0·82
				+1·17						
8 19									+1·32	
9 3					3 5 22·4	+0 18·75	10 14 44·0	24 31·50	+1·32	
9 7				+1·17					+1·41	+1·48
10 10	17 32 42	10 17 4·0	+0 20·31							
				+2·38						
10 19	2 43 9	19 26 0·4	+0 21·22						+1·41	+1·33
				+1·56						
11 19									+1·41	
12 3					2 57 48·0	+0 23·22	10 18 58·5	24 31·38	+1·41	
12 7				+1·56					+1·29	+1·76
13 10	17 42 59	10 15 30·4	+0 25·23							
				+0·43						
14 19	3 3 1	19 30 5·6	+0 25·83						+1·29	+0·76
				+1·04						
15 19									+0·50	
16 4					4 3 20·4	+0 27·10	11 40 27·0	24 31·48	+0·50	
16 7				+1·04					+0·96	+1·30
17 10	17 52 57	10 9 44·8	+0 28·28							
				+0·56						
18 19	3 18 4	19 29 24·4	+0 29·06						+0·96	+0·59
				+1·16						
19 19									+1·12	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer A.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					9 11 18·0	+0 30·84	17 5 0·5	24 31·72		
21 7									+1·12	
22 10	18 28 20	10 25 24·4	+0 33·19	+1·16					+2·30	+1·67
				+2·46						
18 19	3 18 4	19 29 24·4	+0 29·06							
19 19				+1·16			(Kingstown Transit Clock)		+0·96	+0·59
21 5					5 23 26·0	+0 31·81	12 56 29·0	24 31·75	+1·12	
21 7									+1·12	
22 10	18 28 20	10 25 24·4	+0 33·19	+1·16					+2·30	+1·67
22 19	3 19 1	19 14 38·0	+0 34·10	+2·46						
23 19				+2·33			($\frac{1}{2}\Sigma$.)		+2·30	+3·01
24 3					2 55 8·46	+0 37·22	11 3 39·0	24 30·49	+2·46	
24 7									+2·46	
25 10				+2·33					+1·82	+1·73
25 19	3 19 54	19 3 39·6	+0 41·20	+2·46						
26 19									+1·82	+1·93
27 3					3 34 57·2	+0 44·35	11 55 26·0	24 31·53	+2·46	

Concluded Longitude of Kingstown from Greenwich = $24^m\ 31^s{\cdot}18$ West.

Chronometer B.

June 26 19	1 6 11	18 38 5·0	+6 21·81							
27 19				+3·45						+3·30
27 22					22 14 31·2	+6 25·48	4 46 3·0	24 31·16	+2·24	
28 7									+2·24	
29 10	17 16 33	10 37 50·4	+6 30·35	+3·45					+3·73	+3·59
30 19	1 33 44	18 49 42·4	+6 33·35	+2·24						
July 1 19				+3·52					+3·73	+3·90
2 1					1 18 50·0	+6 37·52	8 6 46·5	24 30·76	+2·30	
2 7									+2·30	
				+3·52					+4·35	+3·18

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER B.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by ½.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 16 45	10 22 11·2	+6 42·04							
				+2·36						
3 19	2 9 48	19 13 46·4	+6 42·91							
				+5·69					+4·35	+5·66
4 19									+2·14	
5 2					1 47 14·0	+6 49·29	8 47 13·0	24 31·23	+2·14	
5 7									+4·88	+5·72
				+5·69						
6 10	17 28 10	10 21 36·0	+6 56·06							
				+1·92					+4·88	+3·94
7 19	2 36 30	19 24 29·2	+6 58·71							
				+3·86					+2·15	
8 19									+2·15	
9 3					3 1 26·4	+7 3·36	10 17 33·5	24 31·07	+4·34	+3·79
9 7										
				+3·86					+4·34	+4·96
10 10	17 33 43	10 11 17·2	+7 7·95						+2·26	
				+2·38					+2·26	
10 19	2 44 8	19 20 11·6	+7 8·86						+4·98	+5·28
				+5·13						
11 19									+4·98	+4·64
12 3					2 52 54·0	+7 14·86	10 20 56·5	24 31·34	+2·25	
12 7									+2·25	
				+5·13					+5·60	+5·32
13 10	17 44 10	10 9 45·6	+7 20·83							
				+2·13					+5·60	+5·91
14 19	3 4 34	19 24 40·4	+7 23·77						+3·12	
				+5·00					+3·12	
15 19									+6·44	+6·27
16 4					3 58 20·4	+7 29·82	11 42 30·0	24 31·54		
16 7										
				+5·00						
17 10	17 54 14	10 3 54·4	+7 35·47							
				+2·37						
18 19	3 19 54	19 24 4·4	+7 38·76							
				+6·10						
19 19										
20 9					9 9 21·2	+7 46·36	17 10 21·0	24 30·81		
21 7										
				+6·10						
22 10	18 29 33	10 19 14·0	+7. 56·39							
				+3·77						
18 19	3 19 54	19 24 4·4	+7 38·76							
				+6·10						
19 19							(Kingstown Transit Clock)			
21 5					5 20 15·2	+7 50·46	13 0 37·0	24 32·28		
21 7										
				+6·10						
22 10	18 29 33	10 19 14·0	+7 56·39							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer B.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 20 55	19 9 8·0	+7 57·78	+3·77						
				+6·70					+6·44	+6·64
23 19									+3·77	
24 3					2 51 4·4	+8 5·45	11 7 3·5	24 30·71	+3·77	
24 7				+6·70					+6·03	+6·76
25 10				+3·77						
25 19	3 20 53	18 57 4·4	+8 15·25						+6·03	+5·21
26 19									+3·77	
27 3					3 29 2·8	+8 23·00	11 57 10·0	24 32·06		

Concluded Longitude of Kingstown from Greenwich = 24m 31s·02 West.

Chronometer C.

June 26 19	1 7 25	18 42 26·0	+3 14·60							
				+3·04						+2·96
27 19									+5·23	
27 22					22 19 58·0	+3 18·59	4 48 23·0	24 31·45	+5·23	
28 7				+3·04					+3·17	+3·11
29 10	17 18 6	10 42 29·6	+3 23·90	+5·23						
30 19	1 36 26	18 55 26·4	+3 30·92	+2·19					+3·17	+3·24
July 1 19									+4·78	
2 1					1 24 58·0	+3 34·37	8 9 52·5	24 30·11	+4·78	
2 7				+2·19					+2·71	+1·26
3 10	17 17 44	10 26 14·0	+3 38·08	+4·32						
3 19	2 11 19	19 18 20·4	+3 39·67	+3·66					+2·71	+4·34
4 19									+3·48	
5 2					1 52 4·0	+3 44·30	8 48 59·0	24 30·53	+3·48	
5 7				+3·66					+2·90	+3·08
6 10	17 29 37	10 26 9·6	+3 49·23	+2·64						
7 19	2 39 15	19 30 19·6	+3 52·86	+3·22					+2·90	+2·78
8 19									+3·64	
9 3					3 5 34·0	+3 57·21	10 18 34·5	24 31·69	+3·64	
9 7				+3·22					+3·47	+3·66
10 10	17 35 20	10 16 0·4	+4 1·50							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER C.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by ½ Σ.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 45 17	19 24 26·0	+4 3·27	+4·64						
11 19				+3·45					+3·47	+3·28
12 3					2 58 18·0	+4 7·94	10 23 14·0	24 31·30	+4·20	
12 7									+4·20	
13 10	17 45. 16	10 13 59·6	+4 12·66	+3·45					+2·75	+3·62
14 19	3 5 35	19 28 47·2	+4 17·81	+3·75						
15 19				+2·57					+2·75	+1·77
16 4					4 4 4·4	+4 21·68	11 45 6·0	24 31·82	+4·05	
16 7									+4·05	
17 10	17 55 40	10 8 30·4	+4 25·24	+2·57					+2·93	+3·28
18 19	3 20 43	19 28 0·8	+4 31·23	+4·34						
19 19				+3·32					+2·93	+2·54
20 9					9 13 59·2	+4 35·61	17 11 47·5	24 31·81	+2·08	
21 7									+2·08	
22 10	18 30 45	10 23 40·8	+4 41·39	+3·32					+4·70	+4·02
				+3·47						
18 19	3 20 43	19 28 0·8	+4 31·23							
19 19				+3·32					+2·93	+2·54
21 5					5 26 10·4	+4 37·98	(Kingstown Transit Clock) 13 3 20·0	24 32·43	+2·08	
21 7									+2·08	
22 10	18 30 45	10 23 40·8	+4 41·39	+3·32					+4·70	+4·02
22 19	3 21 38	19 13 6·0	+4 42·67	+3·47						
23 19				+5·38					+4·70	+5·47
24 3					2 55 48·8	+4 48·99	(½ Σ.) 11 8 31·5	24 30·89	+3·47	
24 7									+3·47	
25 10				+5·38					+5·42	+5·30
25 19	3 21 45	19 1 14·4	+4 57·11	+3·47						
26 19									+5·42	+5·55
27 3					3 34 29·6	+5 3·51	11 59 19·0	24 30·72	+3·47	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·22 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer D.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{3}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 8 54	18 45 34·4	+1 34·97							
				+0·89						+1·42
27 19									+0·37	
27 22					22 23 48·0	+1 35·87	4 50 31·5	24 30·58	+0·37	
28 7				+0·89					+0·32	+0·42
29 10	17 19 33	10 45 43·2	+1 37·06	+0·37						
30 19	1 37 26	18 58 19·6	+1 37·56	+0·13					+0·32	+0·21
July 1 19									+0·81	
2 1					1 27 50·8	+1 37·90	8 10 48·0	24 31·08	+0·81	
2 7				+0·13					+1·01	+0·06
3 10	17 19 6	10 29 35·6	+1 38·26	+1·25						
3 19	2 12 9	19 21 11·2	+1 38·72	+1·07					+1·01	+2·08
4 19									+1·55	
5 2					1 56 4·4	+1 40·20	8 50 56·0	24 30·14	+1·55	
5 7				+1·07					+0·97	+0·17
6 10	17 31 7	10 29 46·8	+1 41·78	+1·84						
7 19	2 40 9	19 33 22·0	+1 44·31	+2·40					+0·97	+1·87
8 19									+3·02	
9 3					3 10 27·6	+1 47·63	10 21 19·0	24 31·66	+3·02	
9 7				+2·40					+2·96	+2·87
10 10	17 36 34	10 19 24·8	+1 50·89	+4·20						
10 19	2 46 20	19 27 39·6	+1 52·49	+2·73					+2·96	+3·06
11 19									+2·82	
12 3					3 2 40·0	+1 56·12	10 25 25·0	24 30·84	+2·82	
12 7				+2·73					+2·53	+2·44
13 10	17 46 18	10 17 14·4	+1 59·68	+1·44						
14 19	3 6 27	19 31 55·2	+2 1·67	+3·06					+2·53	+2·63
15 19									+1·51	
16 4					4 7 16·4	+2 5·40	11 46 2·0	24 31·70	+1·51	
16 7				+3·06					+3·12	+3·44
17 10	17 56 33	10 11 39·6	+2 8·89	+1·58						
18 19	3 21 37	19 31 14·8	+2 11·08	+3·68					+3·12	+2·76
19 19										

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER D.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					9 20 40·8	+2 15·83	17 16 10·0	24 31·84	+2·16	
21 7									+2·16	
22 10	18 32 30	10 27 44·8	+2 22·10	+3·68					+4·69	+4·50
				+2·80						
18 19	3 21 37	19 31 14·8	+2 11·08							
19 19				+3·68			(Kingstown Transit Clock)		+3·12	+2·76
21 5					5 31 49·6	+2 18·38	13 6 40·0	24 32·57	+2·16	
21 7									+2·16	
22 10	18 32 30	10 27 44·8	+2 22·10	+3·68					+4·69	+4·50
22 19	3 22 25	19 16 12·4	+2 23·13	+2·80						
23 19				+5·27			($\frac{1}{2}\Sigma$.)		+4·69	+4·91
24 3					3 0 47·6	+2 29·11	11 11 10·5	24 31·24	+2·80	
24 7									+2·80	
25 10				+5·27					+4·18	+5·59
25 19	3 22 36	19 4 25·6	+2 36·76	+2·80						
26 19									+4·18	+2·59
27 3					3 38 0·4	+2 42·81	12 0 26·5	24 33·51	+2·80	

Concluded Longitude of Kingstown from Greenwich = $24^m\ 31^s{\cdot}16$ West.

CHRONOMETER E.

June 26 19	1 10 56	18 49 14·8	−0 3·77							
27 19				+0·94						+0·92
27 22					22 27 51·2	−0 3·32	4 52 55·5	24 30·97	−1·75	
28 7									−1·75	
29 10	17 21 54	10 49 43·6	−0 2·72	+0·94					+0·99	+0·96
30 19	1 38 44	19 1 20·0	−0 5·06	−1·75						
July 1 19				+0·90					+0·99	+1·03
2 1					1 31 42·4	−0 4·52	8 12 57·5	24 31·11	−1·54	
2 7									−1·54	
				+0·90					+0·67	+0·79

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER E.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 20 14	10 32 25·6	−0 3·94							
				−1·33						
3 19	2 13 6	19 23 51·2	−0 4·43							
				+0·70					+0·67	+0·54
4 19									−1·45	
5 2					1 59 49·6	−0 4·07	8 52 56·0	24 31·41		
									−1·45	
5 7										
				+0·70					+0·57	+0·84
6 10	17 32 41	10 33 6·0	−0 3·68							
				−1·56						
7 19	2 41 3	19 36 6·0	−0 5·84							
				+0·27					+0·57	+0·26
8 19									−1·82	
9 3					3 13 41·2	−0 5·99	10 22 39·5	24 31·36		
									−1·82	
9 7										
				+0·27					−0·29	+0·28
10 10	17 38 2	10 22 49·6	−0 6·16							
				−2·07						
10 19	2 47 52	19 31 10·8	−0 6·95							
				−0·51					−0·29	−0·93
11 19									−1·21	
12 3					3 6 48·4	−0 7·80	10 27 29·0	24 31·65		
									−1·21	
12 7										
				−0·51					−0·21	−0·14
13 10	17 48 14	10 21 18·4	−0 8·63							
				−0·34						
14 19	3 7 30	19 35 8·8	−0 9·10							
				−0·82					−0·21	−0·28
15 19									−1·00	
16 4					4 12 11·6	−0 10·26	11 48 43·0	24 30·67		
									−1·00	
16 7										
				−0·82					−0·58	−1·30
17 10	17 57 53	10 15 19·6	−0 11·33							
				−1·65						
18 19	3 23 27	19 35 29·2	−0 13·62							
				−0·20					−0·58	+0·22
19 19									−0·69	
20 9					9 26 2·8	−0 14·25	17 19 3·5	24 30·72		
									−0·69	
21 7										
				−0·20					−0·32	−0·57
22 10	18 33 35	10 31 26·8	−0 15·08							
				−1·95						
18 19	3 23 27	19 35 29·2	−0 13·62							
				−0·20					−0·58	+0·22
19 19							(Kingstown Transit Clock)			
									−0·69	
21 5					5 36 33·6	−0 14·59	13 8 53·0	24 30·96		
									−0·69	
21 7										
				−0·20					−0·32	−0·57
22 10	18 33 35	10 31 26·8	−0 15·08							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER E.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
				−1·95						
22 19	3 23 13	19 19 39·2	−0 15·80						−0·32	−0·04
23 19				+0·41						
24 3					3 4 52·4	−0 16·16	11 12 30·0	24 31·49	−1·95	
24 7									−1·95	
25 10				+0·41					+0·77	+0·81
25 19	3 23 42	19 8 24·8	−0 16·62	−1·95						
26 19									+0·77	+0·73
27 3					3 42 0·8	−0 16·98	12 1 30·0	24 30·78	−1·95	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·17 West.

CHRONOMETER F.

June										
26 19	1 11 56	18 48 32·0	+1 38·86							
27 19				+0·64						+0·09
27 22					22 28 32·8	+1 39·57	4 55 19·5	24 31·85	+0·51	
28 7									+0·51	
29 10	17 23 1	10 49 7·2	+1 40·50	+0·64					+1·89	+1·13
30 19	1 39 40	19 0 29·6	+1 41·19	+0·51						
July				−1·67					+1·89	+2·75
1 19									+0·64	
2 1					1 32 9·6	+1 43·07	8 15 13·5	24 30·27	+0·64	
2 7				+1·67					+0·06	+0·71
3 10	17 21 26	10 31 48·4	+1 45·07	+0·76						
3 19	2 14 30	19 23 25·2	+1 45·35	−0·22					+0·06	−0·68
4 19									+0·49	
5 2					2 0 33·2	+1 45·25	8 55 29·0	24 31·74	+0·49	
5 7				−0·22					+0·06	+0·18
6 10	17 33 54	10 32 30·0	+1 45·14	+0·21						
7 19	2 41 52	19 35 3·6	+1 45·43	+0·59					+0·06	−0·08
8 19									+0·34	
9 3					3 13 46·4	+1 46·15	10 24 36·5	24 32·01	+0·34	
9 7				+0·59					+1·86	+1·19
10 10	17 39 14	10 22 8·4	+1 46·85							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER F.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 50 26	19 31 50·4	+1 47·03	+0·47						
11 19				+2·63					+1·86	+2·62
12 3					3 7 10·8	+1 49·80	10 29 49·5	24 31·53	−0·21	
12 7									−0·21	
13 10	17 49 43	10 20 46·0	+1 52·52	+2·63					+1·47	+2·64
14 19	3 8 47	19 34 25·2	+1 51·29	−0·89						
15 19				+0·83					+1·47	+0·15
16 4					4 11 14·0	+1 52·10	11 49 46·5	24 32·12	−0·40	
16 7									−0·40	
17 10	17 59 11	10 14 33·2	+1 52·86	+0·83					+1·49	+1·43
18 19	3 24 31	19 34 26·4	+1 53·00	+0·10						
19 19				+0·60					+1·49	+1·56
20 9					9 25 29·6	+1 53·24	17 20 38·5	24 30·27	−0·47	
21 7									−0·47	
22 10	18 34 31	10 30 14·0	+1 53·57	+0·60					+0·23	−0·25
				−0·84						
18 19	3 24 31	19 34 26·4	+1 53·00							
19 19				+0·60			(Kingstown Transit Clock)		+1·49	+1·56
21 5					5 35 4·38	+1 53·38	13 9 32·0	24 30·80	−0·47	
21 7									−0·47	
22 10	18 34 31	10 30 14·0	+1 53·57	+0·60					+0·23	−0·25
22 19	3 24 5	19 18 22·0	+1 53·26	−0·84						
23 19				+1·27					+0·23	+0·77
24 3					3 4 36·0	+1 54·11	($\frac{1}{2}\Sigma$.) 11 14 24·0	24 31·67	−0·84	
24 7									−0·84	
25 10				+1·27					+2·46	+1·71
25 19	3 24 36	19 7 6·8	+1 55·23	−0·84						
26 19									+2·46	+3·30
27 3					3 41 12·4	+1 56·10	12 2 56·5	24 29·18	−0·84	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·31 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER G.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 14 26	18 51 34·4	+1 6·07							
				+1·41						+1·32
27 19									+1·98	
27 22					22 31 22·4	+1 7·84	4 57 38·5	24 31·10		
									+1·98	
28 7				+1·41					+1·80	+1·49
29 10	17 25 15	10 51 51·2	+1 10·13							
				+1·98						
30 19	1 40 53	19 2 10·8	+1 12·79						+1·80	+2·15
July				+1·81						
1 19									+1·75	
2 1					1 35 42·4	+1 15·07	8 18 18·5	24 30·57		
									+1·75	
2 7				+1·81					+1·64	+1·51
3 10	17 22 25	10 33 14·8	+1 17·53							
				+1·51						
3 19	2 16 3	19 25 25·2	+1 18·09						+1·64	+1·79
				+1·77						
4 19									+1·72	
5 2					2 2 32·0	+1 20·33	8 57 4·0	24 30·87		
									+1·72	
5 7				+1·77					+1·69	+1·75
6 10	17 35 15	10 34 13·2	+1 22·72							
				+1·92						
7 19	2 43 35	19 37 6·4	+1 25·36						+1·69	+1·62
				+1·97						
8 19									+1·95	
9 3					3 16 36·4	+1 27·96	10 27 9·5	24 31·23		
									+1·95	
9 7				+1·97					+2·34	+2·28
10 10	17 40 5	10 23 15·6	+1 30·52							
				+1·97						
10 19	2 51 22	19 33 2·0	+1 31·27							
				+2·20					+2·34	+2·40
11 19									+1·89	
12 3					3 9 44·8	+1 34·09	10 32 9·0	24 30·70		
									+1·89	
12 7				+2·20					+2·29	+2·02
13 10	17 51 6	10 22 24·4	+1 36·89							
				+1·81						
14 19	3 10 33	19 36 22·8	+1 39·40							
				+2·41					+2·29	+2·60
15 19									+1·97	
16 4					4 14 15·2	+1 42·55	11 52 40·0	24 30·73		
									+1·97	
16 7				+2·41					+1·56	+2·24
17 10	18 0 13	10 15 42·4	+1 45·49							
				+2·13						
18 19	3 25 33	19 35 32·8	+1 48·44							
				+2·08					+1·56	+0·79
19 19										

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer G.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					9 28 5·6	+1 52·24	17 23 12·0	24 32·19	+2·93	
21 7									+2·93	
22 10	18 36 41	10 32 20·0	+1 57·23	+2·08					+4·32	+3·23
				+2·42						
18 19	3 25 33	19 35 32·8	+1 48·44							
19 19				+2·08			(Kingstown Transit Clock)		+1·56	+0·79
21 5					5 37 49·0	+1 54·29	13 12 17·0	24 31·78	+2·93	
21 7									+2·93	
22 10	18 36 41	10 32 20·0	+1 57·23	+2·08					+4·32	+3·23
				+2·42						
22 19	3 24 58	19 19 10·0	+1 58·12	+5·22					+4·32	+5·55
23 19							($\frac{1}{2}\Sigma$.)		+2·42	
24 3					3 7 40·8	+2 3·87	N 17 40·5	24 30·25	+2·42	
24 7				+5·22					+4·45	+4·93
25 10				+2·42						
25 19	3 25 27	19 7 41·6	+2 11·30						+4·45	+3·91
26 19									+2·42	
27 3					3 42 8·8	+2 17·16	12 4 11·5	24 31·86		

Concluded Longitude of Kingstown from Greenwich = 24ᵐ 30ˢ·91 West.

Chronometer H.

June 26 19	1 15 28	18 44 46·4	+8 55·90							
27 19				+7·62						+7·42
27 22					22 26 5·6	+9 3·90	5 0 18·5	24 30·80	+4·68	
28 7									+4·68	
29 10	17 27 13	10 45 44·4	+9 14·62	+7·62					+6·47	+7·80
30 19	1 42 45	18 55 54·4	+9 20·89	+4·68						
July 1 19				+5·37					+6·47	+4·98
2 1									+5·39	
2 7					1 28 10·4	+9 27·71	8 18 58·5	24 31·32	+5·39	
				+5·37					+5·98	+5·72

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER H.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 23 53	10 26 25·0	+ 9 35·08							
				+6·10						
3 19	2 17 0	19 18 2·8	+ 9 37·34							
				+6·82					+5·98	+6·27
4 19										
									+5·25	
5 2					1 56 12·0	+ 9 45·66	8 59 9·0	24 31·55		
									+5·25	
5 7										
				+6·82					+7·35	+7·31
6 10	17 36 19	10 26 45·2	+ 9 54·54							
				+4·40						
7 19	2 44 38	19 29 34·0	+10 0·59							
				+7·02					+7·35	+7·40
8 19										
									+4·82	
9 3					3 10 57·6	+10 9·25	10 30 13·0	24 30·72		
									+4·82	
9 7										
				+7·02					+6·54	+6·68
10 10	17 41 21	10 15 44·0	+10 17·90							
				+5·24						
10 19	2 52 24	19 25 15·2	+10 19·90							
				+6·48					+6·54	+6·38
11 19										
									+5·70	
12 3					3 2 50·8	+10 28·20	10 34 9·0	24 31·13		
									+5·70	
12 7										
				+6·48					+6·81	+6·57
13 10	17 52 37	10 14 55·6	+10 36·45							
				+6·15						
14 19	3 12 10	19 28 54·0	+10 44·93							
				+6·32					+6·81	+7·08
15 19										
									+5·65	
16 4					4 6 29·2	+10 53·31	11 54 5·5	24 30·21		
									+5·65	
16 7										
				+6·32					+6·27	+5·64
17 10	18 1 16	10 7 29·6	+11 1·12							
				+5·15						
18 19	3 26 35	19 27 14·8	+11 8·28							
				+6·59					+6·27	+6·97
19 19										
									+6·52	
20 9					9 20 39·2	+11 18·63	17 25 14·0	24 30·51		
									+6·52	
21 7										
				+6·59					+6·80	+6·25
22 10	18 37 38	10 23 42·0	+11 32·07							
				+5·79						
18 19	3 26 35	19 27 14·8	+11 8·28							
				+6·59					+6·27	+6·97
19 19							(Kingstown Transit Clock)			
									+6·52	
21 5					5 31 20·42	+11 24·08	13 15 20·0	24 30·48		
									+6·52	
21 7										
				+6·59					+6·80	+6·25
22 10	18 37 38	10 23 42·0	+11 32·07							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer H.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 25 47	19 10 22·8	+11 34·19	+5·79						
23 19				+7·31					+6·80	+7·42
24 3					2 59 39·6	+11 43·19	11 19 18·5	24 30·64	+5·79	
24 7									+5·79	
25 10				+7·31					+6·60	+7·21
25 19	3 26 23	18 58 54·0	+11 54·76	+5·79						
26 19									+6·60	+5·91
27 3					3 33 41·6	+12 3·90	12 5 31·0	24 32·12	+5·79	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·05 West.

Chronometer I.

June 26 19	1 16 52	18 54 36·8	+ 0 29·27							
27 19				+3·30						+3·02
27 22					22 36 20·0	+ 0 32·71	5 2 1·5	24 31·28	+1·74	
28 7									+1·74	
29 10	17 28 19	10 55 27·6	+ 0 37·23	+3·30					+2·93	+3·55
30 19	1 43 47	19 5 37·56	+ 0 39·56	+1·74						
July 1 19				+2·77					+2·93	+2·23
2 1					1 39 22·4	+ 0 42·68	8 21 25·5	24 31·68	+1·22	
2 7									+1·22	
3 10	17 26 19	10 37 39·6	+ 0 46·08	+2·77					+2·93	+3·25
3 19	2 18 16	19 28 9·6	+ 0 46·34	+0·70						
4 19				+3·19					+2·93	+2·57
5 2					2 7 22·8	+ 0 49·74	9 1 24·0	24 31·80	+0·53	
5 7									+0·53	
6 10	17 38 39	10 38 6·0	+ 0 53·36	+3·19					+3·53	+3·74
7 19	2 45 33	19 39 35·6	+ 0 53·84	+0·35						
8 19				+2·90					+3·53	+3·30
9 3					3 22 3·2	+ 0 57·01	10 32 6·5	24 30·88	+0·24	
9 7									+0·24	
10 10	17 42 29	10 26 9·6	+ 1 0·12	+2·90					+1·79	+2·54
				+0·13						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER I.—*concluded.*

Comparisons at Greenwich.				Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 53 14	19 35 24·8	+1 0·17							
				+0·93					+1·79	+0·94
11 19									+0·87	
12 3					3 15 5·6	+1 1·37	10 36 57·5	24 31·06		
12 7									+0·87	
				+0·93					+1·81	+0·92
13 10	17 54 17	10 26 9·2	+1 2·57							
				+1·60						
14 19	3 13 0	19 39 24·0	+1 4·79							
				+1·64					+1·81	+2·81
15 19									+1·65	
16 4					4 19 1·2	+1 7·01	11 56 52·0	24 29·87		
16 7									+1·65	
				+1·64					+0·87	+0·60
17 10	18 2 43	10 18 48·4	+1 9·08							
				+1·69						
18 19	3 28 4	19 38 40·4	+1 11·43							
				+0·97					+0·87	+1·17
19 19									+2·56	
20 9					9 33 0·4	+1 13·98	17 27 30·5	24 30·93		
21 7									+2·56	
				+0·97					+1·15	+0·79
22 10	18 38 33	10 34 51·6	+1 17·32							
				+1·46						
18 19	3 28 4	19 38 40·4	+1 11·43							
				+0·97			(Kingstown Transit Clock)		+0·87	+1·17
19 19									+2·56	
21 5					5 43 58·4	+1 15·36	13 17 50·0	24 30·16		
21 7									+2·56	
				+0·97					+1·15	+0·79
22 10	18 38 33	10 34 51·6	+1 17·32							
				+1·46						
22 19	3 26 38	19 21 30·0	+1 17·86							
				+1·26					+1·15	+1·55
23 19							($\frac{1}{2}\Sigma$.)			
24 3					3 11 25·6	+1 19·58	11 20 41·0	24 30·74	+1·46	
24 7									+1·46	
				+1·26					+0·90	+1·00
25 10				+1·46						
25 19	3 27 13	19 10 16·8	+1 21·82						+0·90	+0·79
26 19									+1·46	
27 3					3 50 34·8	+1 23·58	12 11 45·5	24 31·51		

Concluded Longitude of Kingstown from Greenwich = $24^m\ 31^s{\cdot}10$ West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER J.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 18 18	18 56 28·0	+0 3·83							
				+2·90						+2·73
27 19									+0·81	
27 22					22 40 6·4	+0 6·68	5 5 22·5	24 31·20		
									+0·81	
28 7				+2·90					+2·75	+3·05
29 10	17 29 42	10 57 17·2	+0 10·41							
				+0·81						
30 19	1 45 12	19 7 30·4	+0 11·49							
				+2·52					+2·75	+2·41
July 1 19									+1·07	
2 1					1 42 44·4	+0 14·32	8 24 20·0	24 31·30		
									+1·07	
2 7				+2·52					+2·57	+2·62
3 10	17 27 55	10 39 44·0	+0 17·41							
				+1·33						
3 19	2 19 43	19 30 4·8	+0 17·90							
				+2·82					+2·57	+2·52
4 19									+1·71	
5 2					2 10 54·0	+0 21·23	9 4 27·5	24 31·49		
									+1·71	
5 7				+2·82					+2·64	+3·09
6 10	17 39 49	10 39 44·4	+0 24·77							
				+2·08						
7 19	2 46 43	19 41 11·6	+0 27·64							
				+2·13					+2·64	+2·13
8 19									+1·45	
9 3					3 24 34·4	+0 30·27	10 34 11·0	24 31·18		
									+1·45	
9 7				+2·13					+1·99	+2·13
10 10	17 44 2	10 28 9·6	+0 32·86							
				+0·81						
10 19	2 54 26	19 37 3·6	+0 33·17							
				+1·94					+1·99	+1·84
11 19									+1·42	
12 3					3 16 38·4	+0 35·59	10 38 4·5	24 31·26		
									+1·42	
12 7				+1·94					+2·09	+2·03
13 10	17 55 33	10 27 49·6	+0 37·98							
				+2·02						
14 19	3 14 23	19 41 10·8	+0 40·78							
				+2·32					+2·09	+2·16
15 19									+2·00	
16 4					4 21 50·4	+0 43·83	11 59 17·0	24 31·28		
									+2·00	
16 7				+2·32					+2·89	+2·46
17 10	18 5 9	10 21 36·4	+0 46·69							
				+1·98						
18 19	3 29 11	19 40 9·2	+0 49·45							
				+2·74					+2·89	+3·37
19 19									+1·93	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER J.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					9 37 20·0	+0 53·25	17 31 30·5	24 30·45		
									+1·93	
21 7				+2·74					+2·71	+2·18
22 10	18 39 38	10 36 15·6	+0 58·15	+2·57						
18 19	3 29 11	19 40 9·2	+0 49·45							
				+2·74					+2·89	+3·37
19 19							(Kingstown Transit Clock)			
21 5					5 46 42·8	+0 55·25	13 20 14·0	24 30·83	+1·93	
21 7									+1·93	
22 10	18 39 38	10 36 15·6	+0 58·15	+2·74					+2·71	+2·18
				+2·57						
22 19	3 27 37	19 22 47·6	+0 59·09	+3·32					+2·71	+3·30
23 19							($\frac{1}{2}\Sigma$.)			
24 3					3 13 40·0	+1 3·16	11 22 39·0	24 31·05	+2·57	
24 7									+2·57	
25 10				+3·32					+3·40	+3·34
25 19	3 28 43	19 12 0·0	+1 8·37	+2·57						
26 19									+3·40	+3·47
27 3					3 52 0·0	+1 12·56	12 13 0·5	24 30·90	+2·57	

Concluded Longitude of Kingstown from Greenwich = $24^m\ 31^s{\cdot}18$ West.

CHRONOMETER K.

June 26 19	1 20 22	18 59 45·2	−1 9·71							
				0·00						−0·46
27 19									+0·10	
27 22					22 42 50·8	−1 9·69	5 6 51·0	24 30·97	+0·10	
28 7				0·00					+0·29	+0·05
29 10	17 31 23	11 0 18·0	−1 9·67	+0·10						
30 19	1 46 32	19 10 11·2	−1 9·53	−0·41					+0·29	+0·16
July 1 19									+0·05	
2 1					1 47 8·8	−1 9·93	8 27 22·0	24 29·93	+0·05	
2 7				−0·41					−0·28	−0·91

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER K.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 29 3	10 42 19·6	−1 10·37							
				0·00						
3 19	2 21 21	19 33 10·8	−1 10·37							
				+0·34					−0·28	+0·43
4 19										
									−0·41	
5 2					2 14 14·0	−1 10·12	9 6 17·5	24 30·44		
									−0·41	
5 7										
				+0·34					+0·37	+0·26
6 10	17 41 9	10 42 38·8	−1 9·85							
				−0·81						
7 19	2 47 59	19 44 6·0	−1 10·96							
				+0·05					+0·37	+0·50
8 19										
									−0·58	
9 3					3 29 3·2	−1 11·04	10 37 0·0	24 30·13		
									−0·58	
9 7										
				+0·05					+0·15	−0·35
10 10	17 45 15	10 31 6·4	−1 11·13							
				−0·34						
10 19	2 55 57	19 40 18·8	−1 11·26							
				+1·24					+0·15	+0·71
11 19										
									−0·21	
12 3					3 21 22·4	−1 9·98	10 41 3·5	24 31·18		
									−0·21	
12 7										
				+1·24					+1·24	+1·71
13 10	17 57 19	10 31 22·0	−1 8·71							
				−0·07						
14 19	3 15 28	19 44 5·2	−1 8·80							
				+0·57					+1·24	+0·71
15 19										
									+0·19	
16 4					4 26 13·6	−1 8·13	12 1 49·5	24 30·44		
									+0·19	
16 7										
				+0·57					+0·39	+0·45
17 10	18 6 19	10 24 40·4	−1 7·50							
				+0·44						
18 19	3 30 6	19 43 0·4	−1 6·89							
				+0·30					+0·39	+0·33
19 19										
									−0·79	
20 9					9 41 36·0	−1 7·12	17 33 46·5	24 30·45		
									−0·79	
21 7										
				+0·30					−0·22	+0·27
22 10	18 40 45	10 39 28·0	−1 7·44							
				−0·16						
18 19	3 30 6	19 43 0·4	−1 6·89							
				+0·30					+0·39	+0·33
19 19							(Kingstown Transit Clock)			
									−0·79	
21 5					5 51 30·0	−1 7·25	13 22 59·0	24 30·98		
									−0·79	
21 7										
				+0·30					−0·22	+0·27
22 10	18 40 45	10 39 28·0	−1 7·44							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER K.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
				−0·16						
22 19	3 28 49	19 26 6·0	−1 7·50	−0·16					−0·22	−0·78
23 19									−0·16	
24 3					3 16 56·8	−1 7·71	11 23 45·0	24 31·15	−0·16	
24 7				−0·16					+0·63	+0·39
25 10				−0·16						
25 19	3 29 40	19 15 13·2	−1 7·98						+0·63	+0·90
26 19									−0·16	
27 3					3 55 11·2	−1 8·19	12 13 52·5	24 29·47		

Concluded Longitude of Kingstown from Greenwich = 24m 30s·52 West.

CHRONOMETER L.

June										
26 19	1 21 38	19 2 10·4	−2 19·11							
27 19				+0·09						+0·23
27 22					22 47 32·4	−2 19·27	5 10 23·5	24 31·07	−1·06	
28 7									−1·06	
29 10	17 32 45	11 2 49·61	−2 19·50	+0·09					−0·16	−0·03
30 19	1 47 44	19 12 34·4	−2 20·92	−1·06						
July 1 19				−0·06					−0·16	−0·30
2 1					1 50 14·0	−2 21·32	8 29 14·5	24 31·56	−1·36	
2 7									−1·36	
3 10	17 30 17	10 44 44·8	−2 21·76	−0·06					−0·20	+0·15
3 19	2 22 38	19 35 39·6	−2 22·37	−1·66						
4 19				+0·40					−0·20	−0·60
5 2					2 17 50·8	−2 22·41	9 8 40·5	24 32·34	−1·81	
5 7									−1·81	
6 10	17 42 23	10 45 5·2	−2 22·45	+0·40					+0·63	+1·29
7 19	2 49 1	19 46 22·0	−2 25·13	−1·95						
8 19				−0·33					+0·63	−0·11
9 3					3 32 38·8	−2 25·22	10 39 21·0	24 30·94	+1·05	
9 7									+1·05	
10 10	17 46 21	10 33 26·4	−2 25·32	−0·33					+0·01	−0·53
				+4·05						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER L.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 57 46	19 43 20·0	−2 23·77							
				+0·34					+0·01	+0·61
11 19									+1·50	
12 3					3 24 18·4	−2 23·04	10 42 47·0	24 30·89		
12 7									+1·50	
				+0·34					+0·01	+0·10
13 10	17 58 30	10 33 46·4	−2 22·30							
				−1·05						
14 19	3 16 26	19 46 18·0	−2 23·76						+0·01	−0·09
				−0·68						
15 19									−0·18	
16 4					4 29 22·4	−2 24·54	12 3 42·0	24 30·64		
16 7									−0·18	
				−0·68					−0·45	−1·21
17 10	18 7 29	10 27 8·0	−2 25·29							
				+0·69						
18 19	3 31 32	19 45 43·6	−2 24·33						−0·45	+0·40
19 19									+1·75	
20 9					9 44 40·8	−2 22·35	17 35 35·0	24 31·82		
21 7									+1·75	
22 10	18 41 36	10 41 31·2	−2 19·78							
18 19	3 31 32	19 45 43·6	−2 24·33							
							(Kingstown Transit Clock)		−0·45	+0·40
19 19									+1·75	
21 5					5 54 29·2	−2 21·30	13 24 44·0	24 31·40		
21 7									+1·75	
22 10	18 41 36	10 41 31·2	−2 19·78							
22 19										
23 19										
24 3										
24 7										
25 10										
25 19										
26 19										
27 3										

Concluded Longitude of Kingstown from Greenwich = 24m 31s·28 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer M.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by ½ Σ.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 25 58	19 3 35·6	+0 34·98							
				+0·35						+0·05
27 19									−0·68	
27 22					22 47 7·6	+0 35·14	5 12 53·0	24 31·58	−0·68	
28 7				+0·35					−0·31	+0·62
29 10	17 34 55	11 2 4·4	+0 35·36	−0·68						
30 19	1 49 6	19 11 0·8	+0 34·45	−1·67					−0·31	−1·35
July 1 19									−0·29	
2 1					1 49 39·6	+0 32·69	8 31 35·0	24 31·04	−0·29	
2 7				−1·67					−1·31	−1·95
3 10	17 31 55	10 43 30·0	+0 30·76	+0·11						
3 19	2 24 1	19 34 9·2	+0 30·80	−0·94					−1·31	−0·59
4 19									−0·33	
5 2					2 16 48·0	+0 29·76	9 10 31·5	24 31·01	−0·33	
5 7				−0·94					−1·54	−1·25
6 10	17 44 20	10 44 10·8	+0 28·63	−0·76						
7 19	2 50 42	19 45 10·0	+0 27·59	−1·49					−1·54	−1·86
8 19									+0·43	
9 3					3 31 20·4	+0 26·10	10 40 53·5	24 31·61	+0·43	
9 7				−1·49					−0·42	−1·16
10 10	17 47 56	10 32 11·2	+0 24·63	+1·62						
10 19	2 58 50	19 41 34·8	+0 25·25	+0·08					−0·42	+0·41
11 19									+0·52	
12 3					3 25 18·4	+0 25·45	10 46 36·0	24 31·00	+0·52	
12 7				+0·08					+0·07	−0·21
13 10	17 59 53	10 32 21·2	+0 25·67	−0·58						
14 19	3 17 30	19 44 33·2	+0 24·87	+0·13					+0·07	+0·39
15 19									−0·45	
16 4					4 28 19·2	+0 24·90	12 5 28·0	24 31·17	−0·45	
16 7				+0·13					−0·79	−0·10
17 10	18 8 37	10 25 25·6	+0 24·93	−0·32						
18 19	3 32 37	19 43 59·6	+0 24·48	−1·34					−0·79	−1·57
19 19									+0·17	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer M.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					9 45 34·4	+0 23·36	17 39 15·0	24 31·73		
									+0·17	
21 7										
22 10	18 42 33	10 39 46·4	+0 21·87	−1·34					−0·39	−1·14
				−1·19						
18 19	3 32 37	19 43 59·6	+0 24·48							
				−1·34					−0·79	−1·57
19 19							(Kingstown Transit Clock)			
									+0·17	
21 5					5 53 46·4	+0 22·75	13 26 46·0	24 30·98		
									+0·17	
21 7										
				−1·34					−0·39	−1·14
22 10	18 42 33	10 39 46·4	+0 21·87							
				−1·19						
22 19	3 31 40	19 27 27·6	+0 21·43							
				+1·23					−0·39	+0·45
23 19							($\frac{1}{2}\Sigma$.)			
									−1·19	
24 3					3 18 50·8	+0 22·13	11 27 8·5	24 32·05		
									−1·19	
24 7										
				+1·23					+1·74	+1·92
25 10										
				−1·19						
25 19	3 34 27	19 18 28·4	+0 23·03							
									+1·74	+1·54
26 19										
									−1·19	
27 3					3 57 33·2	+0 23·78	12 17 45·5	24 31·08		

Concluded Longitude of Kingstown from Greenwich = 24m 31s·38 West.

Chronometer N.

June										
26 19	1 27 20	19 4 38·8	+0 53·56							
				−0·30						−0·67
27 19									−0·79	
27 22					22 49 3·2	+0 53·11	5 15 7·5	24 31·01		
									−0·79	
28 7										
				−0·30					+0·55	+0·03
29 10	17 36 28	11 3 20·0	+0 52·50							
				−0·79						
30 19	1 52 48	19 14 25·2	+0 51·45							
				+0·06					+0·55	+1·14
July										
1 19									−0·40	
					1 52 32·4	+0 51·41	8 34 48·5	24 29·59		
2 1									−0·40	
2 7										
				+0·06					−0·29	−0·90

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER N.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 33 5	10 44 19·2	+0 51·37							
				0·00						
3 19	2 25 23	19 35 10·4	+0 51·37							
				−0·01					−0·29	+0·39
4 19										
									+0·21	
5 2					2 18 12·8	+0 51·41	9 12 19·0	24 30·24		
									+0·21	
5 7										
				−0·01					−0·22	−0·37
6 10	17 46 36	10 46 3·6	+0 51·45							
				+0·41						
7 19	2 51 43	19 45 46·4	+0 52·02							
				+0·08					−0·22	−0·05
8 19										
									+0·67	
9 3					3 33 36·4	+0 52·27	10 43 37·0	24 30·72		
									+0·67	
9 7										
				+0·08					+0·47	+0·20
10 10	17 49 49	10 33 36·0	+0 52·52							
				+0·92						
10 19	2 59 59	19 42 16·0	+0 52·87							
				+1·46					+0·47	+0·78
11 19										
									+0·18	
12 3					3 27 6·4	+0 54·48	10 48 53·0	24 31·41		
									+0·18	
12 7										
				+1·46					+1·42	+2·06
13 10	18 1 8	10 33 5·6	+0 56·07							
				−0·56						
14 19	3 18 37	19 45 9·6	+0 55·29							
				+0·80					+1·42	+0·69
15 19										
									+0·22	
16 4					4 29 6·8	+0 56·23	12 6 47·5	24 30·81		
									+0·22	
16 7										
				+0·80					+1·04	+0·90
17 10	18 9 59	10 26 15·2	+0 57·10							
				+0·99						
18 19	3 33 56	19 44 44·4	+0 58·47							
				+1·00					+1·04	+1·20
19 19										
									+0·31	
20 9					9 47 34·4	+0 59·59	17 41 53·0	24 30·38		
									+0·31	
21 7										
				+1·00					+0·47	+0·82
22 10	18 43 44	10 40 18·0	+1 1·07							
				−1·63						
18 19	3 33 56	19 44 44·4	+0 58·47							
				+1·00					+1·04	+1·20
19 19							(Kingstown Transit Clock)			
									+0·31	
21 5					5 55 8·38	+1 0·20	13 28 46·0	24 30·73		
									+0·31	
21 7										
				+1·00					+0·47	+0·82
22 10	18 43 44	10 40 18·0	+1 1·07							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer N.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
				−1·63						
22 19	3 32 38	19 27 46·4	+1 0·47							
				+0·86					+0·47	+0·07
23 19										
									−1·63	
24 3					3 20 45·6	+1 0·66	11 29 43·0	24 31·30		
									−1·63	
24 7										
				+0·86					+1·23	+1·56
25 10										
				−1·63						
25 19	3 35 23	19 18 46·4	+1 0·88							
									+1·23	+0·86
26 19										
									−1·63	
27 3					3 58 5·2	+1 1·07	12 18 55·5	24 30·56		

Concluded Longitude of Kingstown from Greenwich = 24m 30s·65 West.

Chronometer O.

June										
26 19	1 29 27	18 55 28·8	+12 10·22							
				+3·03						+3·31
27 19										
									−0·11	
27 22					22 39 46·8	+12 12·99	5 17 11·5	24 30·83		
									−0·11	
28 7										
				+3·03					+2·27	+2·78
29 10	17 38 8	10 53 35·6	+12 16·62							
				−0·11						
30 19	1 53 52	19 4 4·0	+12 16·47							
				+2·84					+2·27	+1·69
July										
1 19									+0·04	
					1 45 29·2	+12 19·39	8 39 11·0	24 32·57		
2 1									+0·04	
2 7										
				+2·84					+3·56	+3·86
3 10	17 34 26	10 34 8·8	+12 22·55							
				+0·19						
3 19	2 26 18	19 24 34·0	+12 22·62							
				+3·04					+3·56	+3·22
4 19										
									+1·31	
5 2					2 9 13·2	+12 26·07	9 14 53·5	24 31·23		
									+1·31	
5 7										
				+3·04					+2·83	+2·88
6 10	17 48 35	10 36 24·0	+12 29·75							
				+2·42						
7 19	2 52 39	19 35 1·2	+12 33·08							
				+2·72					+2·83	+2·78
8 19										
									+1·42	
9 3					3 23 45·2	+12 36·35	10 45 29·5	24 31·40		
									+1·42	
9 7										
				+2·72					+1·28	+2·67
10 10	17 50 45	10 22 44·8	+12 39·57							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER O.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
				+0·42						
10 19	3 0 50	19 31 20·0	+12 39·73							
				+1·06					+1·28	−0·28
11 19										
									+1·38	
12 3					3 17 23·6	+12 41·20	10 50 56·0	24 32·66		
									+1·38	
12 7										
				+1·06					+2·22	+2·25
13 10	18 2 20	10 22 30·8	+12 42·67							
				+2·33						
14 19	3 19 43	19 34 24·8	+12 45·90							
				+1·79					+2·22	+2·18
15 19										
									+1·73	
16 4					4 19 26·0	+12 48·32	12 8 59·0	24 30·96		
									+1·73	
16 7										
				+1·79					+2·67	+1·44
17 10	18 10 53	10 15 15·6	+12 50·55							
				+1·12						
18 19	3 34 59	19 33 53·6	+12 52·10							
				+2·20					+2·67	+4·05
19 19										
									−0·18	
20 9					9 38 40·4	+12 54·00	17 44 55·0	24 29·28		
									−0·18	
21 7										
				+2·20					+1·35	+0·55
22 10	18 44 48	10 29 26·4	+12 56·50							
				0·00						
18 19	3 34 59	19 33 53·6	+12 52·10							
				+2·20					+2·67	+4·05
19 19							(Kingstown Transit Clock)			
									−0·18	
21 5					5 44 56·0	+12 55·03	13 30 29·0	24 30·46		
									−0·18	
21 7										
				+2·20					+1·35	+0·55
22 10	18 44 48	10 29 26·4	+12 56·50							
				0·00						
22 19	3 33 39	19 16 51·2	+12 56·50							
				+2·53					+1·35	+2·25
23 19							($\frac{1}{2}\Sigma$.)			
									0·00	
24 3					3 10 10·8	+12 58·87	11 31 6·5	24 31·44		
									0·00	
24 7										
				+2·53					+3·04	+2·78
25 10										
				0·00						
25 19	3 36 33	19 7 55·2	+13 1·90							
									+3·04	+3·33
26 19										
									0·00	
27 3					3 47 52·0	+13 4·34	12 20 46·0	24 30·42		

Concluded Longitude of Kingstown from Greenwich = 24m 31s·36 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer P.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 6 59	18 50 36·8	−5 22·13							
				−6·40						−5·84
27 19									−5·70	
27 22					23 2 21·2	−5 29·46	5 22 4·5	24 30·58		
									−5·70	
28 7				−6·40					−6·98	−6·90
29 10	17 15 28	10 48 54·8	−5 38·87							
				−5·70						
30 19	1 32 52	19 1 10·4	−5 46·51							
				−6·65					−6·98	−7·07
July 1 19										
									−6·85	
2 1					2 9 12·8	−5 55·26	8 44 42·0	24 31·41		
									−6·85	
2 7				−6·65					−6·38	−6·27
3 10	17 16 19	10 34 31·6	−6 4·29							
				−8·00						
3 19	2 8 22	19 25 10·8	−6 7·25							
				−6·40					−6·38	−6·50
4 19										
									−7·68	
5 2					2 31 34·0	−6 15·85	9 18 33·0	24 31·21		
									−7·68	
5 7				−6·40					−6·26	−6·31
6 10	17 27 5	10 33 52·0	−6 24·75							
				−7·35						
7 19	2 36 6	19 37 38·8	−6 34·83							
				−6·19					−6·26	−6·20
8 19										
									−7·54	
9 3					3 47 58·0	−6 43·50	10 50 23·5	24 31·15		
									−7·54	
9 7				−6·19					−6·38	−6·18
10 10	17 33 8	10 24 41·99	−6 51·75							
				−7·72						
10 19	2 42 39	19 32 46·4	−6 54·70							
				−6·46					−6·38	−6·61
11 19										
									−7·22	
12 3					3 48 15·6	−7 3·68	11 2 6·5	24 31·10		
									−7·22	
12 7				−6·46					−6·13	−6·33
13 10	17 42 12	10 22 20·8	−7 12·04							
				−6·72						
14 19	3 2 55	19 37 46·8	−7 21·35							
				−6·05					−6·13	−5·90
15 19										
									−7·05	
16 4					4 42 34·8	−7 29·95	12 11 50·0	24 30·95		
									−7·05	
16 7				−6·05					−6·30	−6·18
17 10	17 52 43	10 17 36·8	−7 37·68							
				−7·38						
18 19	3 17 59	19 37 36·4	−7 47·93							
				−6·40					−6·30	−6·44
19 19										
									−5·92	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER P.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					10 28 41·82	−7 57·93	18 14 7·5	24 31·04		
21 7									−5·92	
22 10	18 45 50	10 51 35·2	−8 10·47	−6·40					−6·19	−6·37
				−7·09						
18 19	3 17 59	19 37 36·4	−7 47·93							
19 19				−6·40					−6·30	−6·44
21 5									−5·92	
21 7					5 29 50·0	−8 2·93	13 18 17·5	24 30·73	−5·92	
22 10	18 45 50	10 51 35·2	−8 10·47	−6·40					−6·19	−6·37
22 19	3 34 52	19 39 13·6	−8 13·09	−7·09						
23 19				−5·92					−6·19	−5·99
24 3									−7·09	
24 7					3 34 43·6	−8 21·46	11 34 20·0	24 30·92	−7·09	
25 10				−5·92					−5·67	−5·86
25 19	3 37 31	19 30 26·8	−8 31·87	−7·09						
26 19									−5·67	−5·46
27 3					4 12 55·2	−8 40·08	12 24 5·0	24 30·75	−7·09	

Concluded Longitude of Kingstown from Greenwich = 24m 30s·90 West.

CHRONOMETER Q.

June 26 19	1 49 20	19 26 25·56	+1 3·20							
27 19				+1·35						+1·25
27 22					22 59 8·4	+1 5·02	5 25 26·5	24 30·81	+2·70	
28 7									+2·70	
29 10	17 17 9	10 43 49·2	+1 7·46	+1·35					+2·47	+1·44
30 19	1 34 9	18 55 29·6	+1 11·08	+2·70						
July 1 19				+3·35					+2·47	+3·63
2 1									+1·68	
2 7					2 5 34·0	+1 14·99	8 48 15·0	24 30·43	+1·68	
				+3·35					+2·70	+3·10

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER Q.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by ½ Σ.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 17 43	10 28 32·0	+1 19·08							
				+0·65						
3 19	2 9 44	19 19 6·0	+1 19·32							
				+2·01					+2·70	+2·25
4 19										
									+1·25	
5 2					2 26 8·8	+1 21·75	9 20 46·5	24 30·47		
									+1·25	
5 7										
				+2·01					+1·86	+1·80
6 10	17 28 19	10 27 16·8	+1 24·24							
				+1·85						
7 19	2 37 15	19 30 46·0	+1 26·79							
				+2·07					+1·86	+1·93
8 19										
									+1·89	
9 3					3 41 16·4	+1 29·52	10 51 55·5	24 30·82		
									+1·89	
9 7										
				+2·07					+3·25	+2·19
10 10	17 35 7	10 18 16·8	+1 32·13							
				+1·92						
10 19	2 44 6	19 25 45·6	+1 32·86							
				+3·33					+3·25	+4·44
11 19										
									+1·01	
12 3					3 41 1·6	+1 36·80	11 3 34·5	24 29·81		
									+1·01	
12 7										
				+3·33					+2·80	+2·35
13 10	17 44 6	10 15 22·0	+1 40·44							
				+0·09						
14 19	3 4 36	19 30 25·6	+1 40·57							
				+3·38					+2·80	+3·31
15 19										
									−0·60	
16 4					4 35 42·0	+1 44·19	12 14 11·5	24 31·18		
									−0·60	
16 7										
				+3·38					+1·66	+3·44
17 10	17 54 18	10 9 46·4	+1 47·46							
				−1·28						
18 19	3 19 10	19 29 13·6	+1 45·68							
				+1·69					+1·66	−0·34
19 19										
									+1·90	
20 9					10 22 0·48	+1 48·57	18 17 11·5	24 32·69		
									+1·90	
21 7										
				+1·69					+4·08	+3·50
22 10	18 47 2	10 42 44·4	+1 52·14							
				+3·14						
18 19	3 19 10	19 29 13·6	+1 45·68							
				+1·69					+1·66	−0·34
19 19										
									+1·90	
21 5					5 22 5·6	+1 49·98	13 20 24·5	24 32·59		
									+1·90	
21 7										
				+1·69					+4·08	+3·50
22 10	18 47 2	10 42 44·4	+1 52·14							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER Q.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 36 11	19 30 26·0	+1 53·30	+3·14						
				+4·44					+4·08	+4·74
23 19									+3·14	
24 3					3 26 4·0	+1 58·73	11 36 1·5	24 30·29	+3·14	
24 7				+4·44					+3·52	+4·18
25 10				+3·14						
25 19	3 39 3	19 21 21·2	+2 5·49						+3·52	+2·78
26 19									+3·14	
27 3					4 3 22·4	+2 10·99	12 25 22·0	24 32·22		

Concluded Longitude of Kingstown from Greenwich = $24^m\ 30^s{\cdot}68$ West.

CHRONOMETER R.

June										
26 19	1 13 51	18 54 30·8	−2 25·23	−1·17						−1·45
27 19									−4·28	
27 22					23 5 31·6	−2 27·35	5 28 18·0	24 30·60	−4·28	
28 7				−1·17					−0·96	−0·92
29 10	17 18 55	10 49 12·4	−2 30·03	−4·28						
30 19	1 35 42	19 0 49·2	−2 35·77	−1·17					−0·96	−1·00
July										
1 19									−4·76	
2 1					2 13 39·6	−2 38·22	8 52 28·0	24 30·51	−4·76	
2 7				−1·17					−1·19	−1·32
3 10	17 19 11	10 33 59·6	−2 40·76	−5·23						
3 19	2 11 3	19 24 26·8	−2 42·69	−1·42					−1·19	−1·05
4 19									−5·30	
5 2					2 32 50·0	−2 45·51	9 23 21·0	24 30·33	−5·30	
5 7				−1·42					−1·80	−1·75
6 10	17 29 49	10 32 59·2	−2 48·40	−5·36						
7 19	2 38 15	19 36 8·4	−2 55·78	−1·44					−1·80	−1·85
8 19									−3·75	
9 3					3 49 4·0	−2 58·29	10 55 15·5	24 31·16	−3·75	
9 7				−1·44					−0·94	−1·07
10 10	17 36 30	10 24 12·4	−3 0·70	−2·14						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER R.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 45 15	19 31 28·8	−3 1·52							
				−0·42					−0·94	−0·79
11 19									−4·22	
12 3					3 47 58·0	−3 3·06	11 5 50·0	24 31·22	−4·22	
12 7				−0·42					+0·16	−0·09
13 10	17 44 58	10 20 58·8	−3 4·50	−6·29						
14 19	3 5 42	19 36 25·2	−3 13·21	−0·15					+0·16	+0·44
15 19									−4·95	
16 4					4 42 46·8	−3 14·66	12 16 18·5	24 30·48	−4·95	
16 7				−0·15					−0·36	−0·68
17 10	17 55 36	10 16 7·6	−3 15·95	−3·60						
18 19	3 20 34	19 35 44·0	−3 20·95	+0·63					−0·36	0·00
19 19									−4·51	
20 9					10 34 0·0	−3 23·39	18 24 2·0	24 30·87	−4·51	
21 7				+0·63					+0·52	+1·19
22 10	18 47 58	10 48 58·8	−3 26·41	−1·39						
18 19	3 20 34	19 35 44·0	−3 20·95							
19 19				+0·63					−0·36	0·00
21 5					5 30 18·8	−3 24·60	13 23 23·0	24 33·20	−4·51	
21 7									−4·51	
22 10	18 47 58	10 48 58·8	−3 26·41	+0·63					+0·52	+1·19
22 19	3 37 29	19 37 4·0	−3 26·92	−1·39						
23 19				+0·49					+0·52	−0·24
24 3					3 34 19·6	−3 27·00	11 38 51·0	24 31·11	−1·39	
24 7									−1·39	
25 10				+0·49					+2·14	+1·14
25 19	3 40 9	19 27 59·6	−3 27·09	−1·39						
26 19									+2·14	+3·27
27 3					4 9 58·8	−3 27·17	12 26 25·0	24 27·62	−1·39	

Concluded Longitude of Kingstown from Greenwich = 24m 30s·45 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer S.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 16 3	18 52 38·0	+1 39·20							
				+11·19						+11·91
27 19										
									+ 4·96	
27 22					23 8 30·0	+1 50·80	5 35 37·0	24 29·84		
									+ 4·96	
28 7				+11·19					+ 9·22	+10·55
29 10	17 20 35	10 46 16·4	+2 5·69							
				+ 4·96						
30 19	1 37 24	18 57 42·8	+2 12·35							
				+ 9·62					+ 9·22	+ 7·72
July 1 19										
									+ 6·59	
2 1					2 10 17·6	+2 24·03	8.54 6·5	24 32·54		
									+ 6·59	
2 7				+ 9·62					+ 9·41	+11·31
3 10	17 20 25	10 29 56·4	+2 36·24							
				+ 8·21						
3 19	2 12 30	19 20 31·6	+2 39·27							
				+ 7·38					+ 9·41	+ 7·28
4 19									+ 8·81	
5 2					2 29 43·6	+2 49·19	9 25 49·5	24 30·54		
									+ 8·81	
5 7				+ 7·38					+ 6·70	+ 7·47
6 10	17 33 9	10 30 30·8	+2 59·45							
				+ 9·41						
7 19	2 39 43	19 31 28·0	+3 12·38							
				+ 8·61					+ 6·70	+ 5·83
8 19									+ 7·42	
9 3					3 46 21·2	+3 23·63	10 58 53·0	24 33·36		
									+ 7·42	
9 7				+ 8·61					+11·17	+11·08
10 10	17 38 13	10 19 20·0	+3 34·42							
				+ 5·42						
10 19	2 46 22	19 25 57·6	+3 36·49							
				+ 9·40					+11·17	+11·27
11 19									+ 5·47	
12 3					3 43 45·2	+3 48·09	11 8 31·0	24 29·00		
									+ 5·47	
12 7				+ 9·40					+ 8·18	+ 7·74
13 10	17 46 48	10 15 44·8	+3 59·20							
				+ 5·51						
14 19	3 6 41	19 30 4·0	+4 6·82							
				+ 6·84					+ 8·18	+ 8·68
15 19									+ 4·32	
16 4					4 37 29·2	+4 15·62	12 18 33·0	24 29·02		
									+ 4·32	
16 7				+ 6·84					+ 5·75	+ 5·20
17 10	17 56 32	10 9 24·0	+4 23·49							
				+ 3·12						
18 19	3 21 55	19 29 16·0	+4 27·83							
				+8·12					+ 5·75	+ 6·36
19 19									+ 8·04	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer S.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					10 28 55·6	+4 40·93	18 27 1·0	24 32·28		
21 7									+8·04	
22 10	18 49 8	10 41 45·0	+4 57·20	+8·12					+9·70	+9·68
				+7·18						
18 19	3 21 55	19 29 16·0	+4 27·83							
19 19				+8·12					+5·75	+6·36
21 5					5 23 32·8	+4 47·33	13 24 50·0	24 32·36	+8·04	
21 7									+8·04	
22 10	18 49 8	10 41 45·0	+4 57·20	+8·12					+9·70	+9·68
22 19	3 38 54	19 30 2·0	+4 59·85	+7·18						
23 19				+6·20					+9·70	+9·72
24 3					3 28 9·2	+5 8·47	11 41 20·5	24 27·08	+7·18	
24 7									+7·18	
25 10				+6·20					+4·60	+3·07
25 19	3 41 26	19 20 30·0	+5 19·30	+7·18						
26 19									+4·60	+6·32
27 3					4 2 37·6	+5 28·07	12 27 56·5	24 30·42	+7·18	

Concluded Longitude of Kingstown from Greenwich = $24^m\ 30^s{\cdot}67$ West.

Chronometer T.

June										
26 19	1 18 8	18 55 46·8	+0 35·06							
27 19				+0·56						+0·33
27 22					23 13 40·8	+0 35·82	5 39 31·5	24 31·31	+1·00	
28 7									+1·00	
29 10	17 22 26	10 49 36·0	+0 36·79	+0·56					+0·75	+0·76
30 19	1 38 40	19 0 32·8	+0 38·14	+1·00						
July				+0·28					+0·75	+0·73
1 19									+1·00	
2 1					2 15 2·0	+0 38·68	8 57 8·0	24 30·57	+1·00	
2 7				+0·28					−0·13	−0·12

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER T.—*continued.*

Comparisons at Greenwich.				Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 21 31	10 32 59·2	+0 39·26							
				+1·00						
3 19	2 14 1	19 24 2·0	+0 39·63							
				−0·03					−0·13	−0·14
4 19									+0·72	
5 2					2 35 1·6	+0 39·78	9 28 58·0	24 31·14		
5 7									+0·72	
				−0·03					+0·18	+0·07
6 10	17 33 54	10 33 35·2	+0 39·93							
				+0·44						
7 19	2 41 9	19 35 25·6	+0 40·54							
				+0·45					+0·18	+0·31
8 19									+0·58	
9 3					3 52 32·4	+0 41·17	11 2 24·5	24 31·18		
9 7									+0·58	
				+0·45					+0·70	+0·58
10 10	17 39 37	10 23 36·4	+0 41·79							
				+0·71						
10 19	2 47 49	19 30 18·8	+0 42·06							
				+0·64					+0·70	+0·84
11 19									+0·57	
12 3					3 49 2·4	+0 42·90	11 10 41·5	24 30·87		
12 7									+0·57	
				+0·64					+0·55	+0·46
13 10	17 48 38	10 20 50·0	+0 43·70							
				+0·42						
14 19	3 7 35	19 34 20·4	+0 44·28							
				+0·55					+0·55	+0·65
15 19									+0·85	
16 4					4 43 29·2	+0 45·11	12 21 1·0	24 30·92		
16 7									+0·85	
				+0·55					+0·02	+0·46
17 10	17 57 59	10 14 28·4	+0 45·86							
				+1·28						
18 19	3 23 5	19 34 6·0	+0 47·64							
				+0·52					+0·02	−0·48
19 19									+1·13	
20 9					10 34 51·6	+0 48·89	18 29 5·5	24 32·07		
21 7									+1·13	
				+0·52					+2·37	+1·40
22 10	18 50 2	10 46 45·6	+0 50·45							
				+0·03						
18 19	3 23 5	19 34 6·0	+0 47·64							
				+0·52					+0·02	−0·48
19 19									+1·13	
21 5					5 32 6·8	+0 49·50	13 29 27·5	24 31·79		
21 7									+1·13	
				+0·52					+2·37	+1·40
22 10	18 50 2	10 46 45·6	+0 50·45							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer T.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 40 6	19. 35. 23·2	+0. 50·46	+0·03						
23 19				+3·13					+2·37	+3·45
24 3					3. 34. 24·4	+0. 53·44	11. 43. 17·5	24. 30·58	+0·03	
24 7									+0·03	
25 10				+3·13					+2·33	+2·84
25 19	3 42 20	19. 25. 46·0	+0. 57·15	+0·03						
26 19									+2·33	+1·75
27 3					4. 8. 15·2	+1. 0·17	12. 29. 4·5	24. 32·31	+0·03	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·07 West.

Chronometer U.

June 26 19	1 20 45	18 57 30·4	+1 28·03							
27 19				+4·72						+5·09
27 22					23 17 55·6	+1 33·12	5 44 45·0	24 30·75	+2·78	
28 7									+2·78	
29 10	17 23 45	10 49 52·0	+1 39·58	+4·72					+4·32	+4·39
30 19	1 40 5	19 0 52·4	+1 43·31	+2·78						
July 1 19				+3·72					+4·32	+4·24
2 1					2 15 40·8	+1 48·26	8 58 56·5	24 30·74	+4·16	
2 7									+4·16	
3 10	17 23 7	10 33 20·8	+1 53·40	+3·72					+4·14	+3·26
3 19	2 15 7	19 23 52·0	+1 55·44	+5·53						
4 19				+4·97					+4·14	+5·13
5 2					2 35 51·6	+2 1·86	9 31 10·5	24 31·09	+4·96	
5 7									+4·96	
6 10	17 35 0	10 33 12·4	+2 8·55	+4·97					+4·60	+4·82
7 19	2 42 10	19 34 52·4	+2 14·58	+4·38						
8 19				+4·77					+4·60	+4·35
9 3					3 52 18·0	+2 20·90	11 3 49·5	24 31·73	+4·54	
9 7									+4·54	
10 10	17 40 48	10 23 2·0	+2 26·99	+4·77					+5·00	+5·15
				+4·69						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER U.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 49 30	19 30 12·8	+2 28·78							
				+5·29					+5·00	+4·83
11 19									+4·78	
12 3					3 49 21·6	+2 35·75	11 12 53·0	24 31·79	+4·78	
12 7									+5·14	+5·69
13 10	17 49 32	10 19 45·2	+2 42·36	+5·29						
14 19	3 8 46	19 33 26·4	+2 49·09	+4·87					+5·14	+4·52
15 19				+5·50					+5·46	
16 4					4 43 25·6	+2 56·65	12 23 8·0	24 32·21	+5·46	
16 7									+5·89	+6·37
17 10	17 59 8	10 13 19·6	+3 3·47	+5·50						
18 19	3 24 15	19 32 51·6	+3 11·85	+6·05					+5·89	+5·35
19 19				+4·40					+6·28	
20 9					10 36 26·4	+3 20·27	18 33 14·0	24 30·42	+6·28	
21 7									+4·10	+3·56
22 10	18 51 6	10 45 9·2	+3 30·67	+4·40						
				+5·45						
18 19	3 24 15	19 32 51·6	+3 11·85							
				+4·40					+5·89	+5·35
19 19									+6·28	
21 5					5 31 24·4	+3 24·40	13 31 22·5	24 29·60	+6·28	
21 7				+4·40					+4·10	+3·56
22 10	18 51 6	10 45 9·2	+3 30·67							
				+5·45						
22 19	3 41 10	19 33 44·8	+3 32·68	+5·15					+4·10	+4·71
23 19									+5·45	
24 3					3 32 23·2	+3 39·68	11 44 1·5	24 31·73	+5·45	
24 7				+5·15					+5·84	+5·54
25 10				+5·45						
25 19	3 43 23	19 23 57·6	+3 48·38						+5·84	+6·17
26 19									+5·45	
27 3					4 6 37·6	+3 55·47	12 30 24·5	24 30·22		

Concluded Longitude of Kingstown from Greenwich = 24^{m} 31^{s}·38 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer W.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 24 17	19 8 15·6	−5 45·75							
				−7·98						−7·33
27 19									−8·69	
27 22					23 27 54·2	−5 55·25	5 47 16·0	24 30·39	−8·69	
28 7				−7·93					−8·40	−8·46
29 10	17 25 17	10 59 10·6	−6 7·27	−8·69						
30 19	1 41 20	19 10 9·4	−6 18·90	−8·24					−8·40	−8·33
July 1 19									−7·47	
2 1					2 26 57·8	−6 29·40	9 1 56·0	24 31·08	−7·47	
2 7				−8·24					−8·03	−8·16
3 10	17 24 51	10 43 38·2	−6 40·28	−6·24						
3 19	2 16 33	19 33 55·8	−6 42·59	−8·00					−8·03	−7·88
4 19									−6·80	
5 2					2 47 25·0	−6 52·77	9 33 50·0	24 30·79	−6·80	
5 7				−8·00					−8·01	−8·10
6 10	17 36 6	10 43 29·8	−7 3·04	−7·35						
7 19	2 43 1	19 45 11·0	−7 13·15	−7·73					−8·01	−7·90
8 19									−7·41	
9 3					4 4 13·0	−7 23·55	11 6 1·0	24 31·13	−7·41	
9 7				−7·73					−7·70	−7·58
10 10	17 42 11	10 34 25·0	−7 33·23	−7·46						
10 19	2 51 4	19 41 51·4	−7 36·08	−6·90					−7·70	−7·84
11 19									−7·99	
12 3					4 2 49·4	−7 45·68	11 15 59·5	24 32·16	−7·99	
12 7				−6·90					−6·83	−6·06
13 10	17 50 56	10 31 46·0	−7 54·68	−8·52						
14 19	3 9 46	19 45 21·8	−8 6·48	−7·81					−6·83	−7·69
15 19									−7·74	
16 4					4 57 39·4	−8 17·31	12 26 9·5	24 31·03	−7·74	
16 7				−7·81					−7·21	−7·92
17 10	18 2 22	10 28 3·4	−8 26·86	−6·96						
18 19	3 25 27	19 45 51·8	−8 36·54	−7·02					−7·21	−6·42
19 19									−9·44	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER W.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					10 55 5·8	−8 49·71	18 39 44·5	24 30·41		
21 7									−9·44	
22 10	18 52 20	10 58 59·4	−9 5·72	−7·02					−8·17	−7·56
				−8·00						
18 19	3 25 27	19 45 51·8	−8 36·54							
19 19				−7·02					−7·21	−6·42
21 5					5 45 57·4	−8 55·94	13 33 33·5	24 31·62	−9·44	
21 7									−9·44	
22 10	18 52 20	10 58 59·4	−9 5·72	−7·02					−8·17	−7·56
22 19	3 42 5	19 47 21·0	−9 8·67	−8·00						
23 19				−8·80					−8·17	−8·86
24 3					3 46 59·8	−9 20·12	11 45 39·0	24 31·30	−8·00	
24 7									−8·00	
25 10				−8·80					−8·42	−8·75
25 19	3 44 23	19 38 20·2	−9 34·38	−8·00						
26 19									−8·42	−8·05
27 3					4 21 30·2	−9 45·98	12 31 35·5	24 30·56	−8·00	

Concluded Longitude of Kingstown from Greenwich = 24ᵐ 30ˢ·97 West.

CHRONOMETER X.

June 26 19	1 27 45	19 5 51·0	+0 6·29							
27 19				−0·63						−0·40
27 22					23 25 53·4	+0 5·39	5 51 16·0	24 30·89	−1·32	
28 7									−1·32	
29 10	17 27 2	10 54 43·8	+0 4·25	−0·63					−1·02	−0·83
30 19	1 42 48	19 5 15·8	+0 2·48	−1·32						
July 1 19				−1·34					−1·02	−1·23
2 1					2 23 55·0	+0 0·80	9 5 24·0	24 31·03	−1·06	
2 7									−1·06	
				−1·34					−1·22	−1·44

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER X.—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 26 21	10 38 28·6	−0 0·92							
				−0·79						
3 19	2 17 55	19 28 36·2	−0 1·21							
				−1·06					−1·22	−0·97
4 19									−1·03	
5 2					2 44 11·0	−0 2·58	9 37 26·5	24 31·07		
									−1·03	
5 7				−1·06					−1·24	−1·14
6 10	17 37 8	10 37 32·6	−0 4·00							
				−1·27						
7 19	2 44 11	19 39 13·4	−0 5·75							
				−1·29					−1·24	−1·36
8 19									−1·15	
9 3					3 59 20·6	−0 7·47	11 8 25·0	24 31·19		
9 7									−1·15	
10 10	17 43 41	10 28 30·6	−0 9·08	−1·29					−1·53	−1·23
				−1·02						
10 19	2 52 14	19 35 34·6	−0 9·47							
				−1·52					−1·53	−1·87
11 19									−1·19	
12 3					3 56 48·2	−0 11·45	11 17 33·5	24 31·44		
12 7									−1·19	
13 10	17 52 21	10 25 29·4	−0 13·31	−1·52					−1·39	−1·21
				−1·35						
14 19	3 11 36	19 39 20·2	−0 15·18							
				−1·35					−1·39	−1·59
15 19									−1·09	
16 4					4 51 14·6	−0 16·98	12 27 45·0	24 31·32		
16 7									−1·09	
17 10	18 3 6	10 20 39·0	−0 18·58	−1·35					−0·91	−1·14
				−0·82						
18 19	3 26 34	19 38 41·8	−0 19·72							
				−1·33					−0·91	−0·66
19 19									−1·45	
20 9					10 47 47·4	−0 21·97	18 40 54·0	24 30·44		
21 7									−1·45	
22 10	18 53 26	10 51 24·2	−0 24·71	−1·33					−2·03	−1·93
				−1·33						
18 19	3 26 34	19 38 41·8	−0 19·72							
				−1·33					−0·91	−0·66
19 19									−1·45	
21 5					5 39 10·6	−0 23·06	13 35 21·0	24 30·49		
21 7									−1·45	
22 10	18 53 26	10 51 24·2	−0 24·71	−1·33					−2·03	−1·93

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer X.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 42 55	19 39 27·4	−0 25·20	−1·33						
23 19				−1·72					−2·03	−2·14
24 3					3 39 28·6	−0 27·34	11 47 0·5	24 31·60	−1·33	
24 7									−1·33	
25 10				−1·72					−0·99	−1·34
25 19	3 45 44	19 30 36·6	−0 30·01	−1·33						
26 19									−0·99	−0·59
27 3					4 14 4·6	−0 32·18	12 33 24·5	24 30·06	−1·33	

Concluded Longitude of Kingstown from Greenwich = 24m. 31s·12 West.

Chronometer Y.

June 26 19	1 29 19	19 5 8·0	+2 23·04							
27 19				+1·96						+0·61
27 22									+0·95	
28 7					23 26 37·0	+2 25·12	5 54 18·5	24 32·21	+0·95	
29 10	17 28 59	10 54 17·0	+2 27·72	+1·96					+2·52	+3·16
30 19	1 44 34	19 4 35·0	+2 28·99	+0·95						
July 1 19				+2·09					+2·52	+1·80
2 1									+1·74	
2 7					2 37 32·2	+2 31·65	9 21 34·5	24 31·20	+1·74	
3 10	17 28 15	10 37 47·0	+2 34·36	+2·09					+1·74	+2·35
3 19	2 19 45	19 27 49·4	+2 35·29	+2·52						
4 19				+1·73					+1·74	+1·06
5 2									+1·84	
5 7					2 43 37·0	+2 37·58	9 39 32·5	24 31·58	+1·84	
6 10	17 38 51	10 36 31·4	+2 39·91	+1·73					+2·75	+2·38
7 19	2 45 10	19 37 25·0	+2 41·49	+1·15						
8 19				+2·59					+2·75	+3·22
9 3									+0·62	
9 7					3 58 51·0	+2 44·49	11 10 48·5	24 30·45	+0·62	
10 10	17 45 2	10 26 55·0	+2 47·30	+2·59					+2·64	+2·03

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER Y.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 53 27	19 33 50·6	+2 47·33	+0·08						
				+2·54					+2·64	+3·33
11 19									+1·03	
12 3					3 57 10·6	+2 50·38	11 20 59·5	24 30·23	+1·03	
12 7				+2·54					+2·53	+1·84
13 10	17 53 51	10 23 52·6	+2 53·24	+1·98						
14 19	3 13 1	19 37 33·8	+2 55·99	+2·33					+2·53	+3·31
15 19									+1·85	
16 4					4 50 40·2	+2 59·09	12 30 28·5	24 29·94	+1·85	
16 7				+2·33					+1·54	+1·46
17 10	18 4 3	10 18 15·4	+3 1·86	+1·72						
18 19	3 28 1	19 36 44·6	+3 4·24	+2·28					+1·54	+1·63
19 19									+3·07	
20 9					10 47 8·6	+3 8·47	18 43 45·0	24 31·54	+3·07	
21 7				+2·28					+3·20	+2·86
22 10	18 54 33	10 48 52·6	+3 13·71	+3·65						
18 19	3 28 1	19 36 44·6	+3 4·24							
19 19				+2·28					+1·54	+1·63
21 5					5 38 3·8	+3 10·54	13 37 47·5	24 31·20	+3·07	
21 7									+3·07	
22 10	18 54 33	10 48 52·6	+3 13·71	+2·28					+3·20	+2·86
22 19	3 43 47	19 36 39·0	+3 15·05	+3·65						
23 19				+4·02					+3·20	+3·59
24 3					3 36 47·0	+3 20·25	11 48 7·0	24 31·27	+3·65	
24 7									+3·65	
25 10				+4·02					+4·37	+4·41
25 19	3 47 9	19 28 4·6	+3 26·77	+3·65						
26 19									+4·37	+4·33
27 3					4 11 12·6	+3 32·05	12 34 36·5	24 30·48	+3·65	

Concluded Longitude of Kingstown from Greenwich = $24^m\ 30^s{\cdot}93$ West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER Z.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 32 10	19 8 58·6	+1 22·97							
				+1·77						+1·53
27 19										
									+0·86	
27 22					23 30 45·0	+1 24·85	5 57 28·0	24 30·96		
									+0·86	
28 7										
				+1·77					+1·88	+1·98
29 10	17 30 58	10 57 16·2	+1 27·20							
				+0·86						
30 19	1 46 0	19 7 1·4	+1 28·35							
				+1·80					+1·88	+1·76
July 1 19										
									+1·72	
2 1					3 13 10·6	+1 30·73	9 56 18·0	24 30·80		
									+1·72	
2 7										
				+1·80					+1·69	+1·83
3 10	17 30 0	10 40 33·0	+1 33·08							
				+2·57						
3 19	2 21 22	19 30 27·4	+1 34·03							
				+2·48					+1·69	+1·53
4 19										
									+2·78	
5 2					2 46 49·0	+1 37·35	9 41 44·5	24 31·71		
									+2·78	
5 7										
				+2·48					+2·65	+3·32
6 10	17 40 8	10 38 47·4	+1 40·72							
				+2·98						
7 19	2 46 46	19 39 57·4	+1 44·83							
				+2·13					+2·65	+1·89
8 19										
									+2·23	
9 3					4 2 11·4	+1 47·75	11 13 12·0	24 31·00		
									+2·23	
9 7										
				+2·13					+2·67	+2·34
10 10	17 46 31	10 29 20·6	+1 50·46							
				+1·47						
10 19	2 55 25	19 36 44·6	+1 51·02							
				+2·67					+2·67	+3·04
11 19										
									+1·89	
12 3					4 1 9·8	+1 54·44	11 24 3·0	24 30·48		
									+1·89	
12 7										
				+2·67					+2·22	+2·34
13 10	17 55 14	10 26 11·0	+1 57·63							
				+2·30						
14 19	3 14 10	19 39 37·8	+2 0·81							
				+2·16					+2·22	+2·08
15 19										
									+1·42	
16 4					4 54 36·2	+2 3·61	12 33 28·5	24 30·95		
									+1·42	
16 7										
				+2·16					+2·85	+2·23
17 10	18 5 3	10 20 11·0	+2 6·11							
				+0·54						
18 19	3 29 9	19 38 49·8	+2 6·86							
				+3·09					+2·85	+3·55
19 19										
									−0·20	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer Z.—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by ½ Σ.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					10 52 1·4	+2 9·67	18 47 41·0	24 30·18		
									−0·20	
21 7				+3·09					+4·44	+2·67
22 10	18 55 51	10 51 11·0	+2 13·10	+1·57						
18 19	8 29 9	19 38 49·8	+2 6·86							
				+3·09					+2·85	+3·55
19 19									−0·20	
21 5					5 41 35·4	+2 11·03	13 40 19·5	24 31·70	−0·20	
21 7				+3·09					+4·44	+2·67
22 10	18 55 51	10 51 11·0	+2 13·10							
				+1·57						
22 19	8 44 53	19 38 46·2	+2 13·68	+6·00					+4·44	+6·42
23 19									+1·57	
24 3					3 41 8·6	+2 19·97	11 51 30·0	24 30·13	+1·57	
24 7				+6·00					+4·22	+5·64
25 10				+1·57						
25 19	8 49 20	19 31 14·2	+2 27·81						+4·22	+2·64
26 19									+1·57	
27 3					4 14 10·6	+2 34·23	12 36 33·5	24 33·99		

Concluded Longitude of Kingstown from Greenwich = 24m. 30s·80 West.

Chronometer *a*.

June 26 19	1 35 14	19 14 7·4	−0 42·33							
				−1·72						−2·25
27 19									−3·90	
27 22					23 37 49·8	−0 44·88	6 2 24·0	24 30·83		
28 7									−3·90	
				−1·72					−1·34	−1·25
29 10	17 32 39	11 1 13·2	−0 48·07							
				−3·90						
30 19	1 47 29	19 10 51·8	−0 53·29							
				−1·00					−1·34	−1·44
July 1 19									−3·33	
2 1					3 19 12·2	−0 55·21	9 59 54·0	24 31·06		
2 7									−3·33	
				−1·00					−1·21	−0·61

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *a.—continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 31 28	10 44 31·0	−0 57·16							
				−2·76						
3 19	2 22 40	19 34 17·4	−0 58·18							
				−1·15					−1·21	−1·89
4 19									−2·13	
5 2					2 54 17·0	−0 59·93	9 46 36·5	24 31·22		
									−2·13	
5 7										
				−1·15					+0·10	−0·49
6 10	17 41 35	10 42 56·6	−1 1·72							
				−1·49						
7 19	2 48 0	19 43 59·8	−1 3·77							
				+0·45					+0·10	+0·77
8 19									−1·57	
9 3					4 7 28·2	−1 3·68	11 15 38·5	24 30·28		
									−1·57	
9 7										
				+0·45					+0·55	+0·17
10 10	17 48 6	10 33 49·4	−1 3·59							
				−1·65						
10 19	2 56 50	19 41 4·6	−1 4·22							
				+0·66					+0·55	+0·98
11 19									−1·87	
12 3					4 7 0·6	−1 3·96	11 26 56·0	24 30·36		
									−1·87	
12 7										
				+0·66					+0·96	+0·38
13 10	17 57 27	10 31 25·0	−1 3·73							
				−2·08						
14 19	3 15 28	19 44 3·0	−1 6·61							
				+0·66					+0·96	+1·62
15 19									−1·50	
16 4					5 11 6·2	−1 6·25	12 46 52·0	24 29·76		
									−1·50	
16 7										
				+0·66					+0·24	−0·19
17 10	18 6 28	10 24 47·8	−1 5·93							
				−0·91						
18 19	3 30 36	19 43 30·6	−1 7·19							
				+1·13					+0·24	+0·73
19 19									−0·17	
20 9					10 57 4·6	−1 6·23	18 49 28·0	24 30·77		
									−0·17	
21 7										
				+1·13					+1·22	+1·49
22 10	18 56 47	10 55 25·0	−1 5·05							
				−1·19						
18 19	3 30 36	19 43 30·6	−1 7·19							
				+1·13					+0·24	+0·73
19 19									−0·17	
21 5					5 47 3·0	−1 5·75	13 42 31·0	24 31·38		
									−0·17	
21 7										
				+1·13					+1·22	+1·49
22 10	18 56 47	10 55 25·0	−1 5·05							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

Chronometer *a.*—*concluded.*

Approximate Solar Time, 1844.	Comparisons at Greenwich: Time by Greenwich Transit Clock.	Comparisons at Greenwich: Corresponding Time by Chronometer.	Comparisons at Greenwich: Chronometer Slow.	Comparisons at Greenwich: Chronometer's Apparent Losing Rate.	Comparisons at Kingstown: Time by Chronometer.	Comparisons at Kingstown: Chronometer Error employed.	Comparisons at Kingstown: Corresponding Time by $\frac{1}{2}\Sigma$.	Comparisons at Kingstown: Resulting Difference of Longitude.	Comparisons at Kingstown: Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 45 52	19 43 4·2	−1 5·49	−1·19						
23 19				+1·35					+1·22	+0·92
24 3					3 45 50·6	−1 4·69	11 52 47·0	24 30·69	−1·19	
24 7									−1·19	
25 10				+1·35					+1·48	+1·74
25 19	3 51 0	19 36 25·4	−1 3·66	−1·19						
26 19									+1·48	+1·19
27 3					4 20 28·2	−1 2·82	12 39 18·0	24 30·46	−1·19	

Concluded Longitude of Kingstown from Greenwich = 24m 30s·39 West.

Chronometer *b.*

June 26 19	1 37 33	19 15 22 2	+0 21·49							
27 19				+3·82						+3·66
27 22					23 41 4·6	+0 25·10	6 6 49·5	24 30·83	+0·03	
28 7									+0·03	
29 10	17 34 21	11 1 36·2	+0 29·65	+3·82					+3·40	+3·96
30 19	1 48 47	19 10 46·6	+0 29·69	+0·03						
July 1 19				+2·69					+3·40	+2·77
2 1					3 20 0·6	+0 32·49	10 2 10·5	24 31·03	−0·30	
2 7									−0·30	
3 10	17 32 37	10 44 7·4	+0 35·25	+2·69					+1·99	+2·62
3 19	2 23 53	19 33 57·0	+0 35·02	−0·62						
4 19				+1·94					+1·99	+1·28
5 2					2 55 29·8	+0 37·60	9 49 27·0	24 31·51	+2·14	
5 7									+2·14	
6 10	17 43 8	10 42 47·4	+0 40·23	+1·94					+3·74	+2·53
7 19	2 49 31	19 43 39·8	+0 46·98	+4·90						
8 19				+4·02					+3·74	+5·11
9 3					4 9 15·8	+0 52·23	11 19 23·0	24 29·88	+3·25	
9 7									+3·25	
10 10	17 49 49	10 33 31·4	+0 57·13	+4·02					+3·42	+3·06
				+1·60						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *b.—concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by ½ Σ.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	2 58 21	19 40 33·4	+0 57·74							
				+3·29					+3·42	+3·83
11 19									+1·97	
12 3					4 7 15·0	+1 1·89	11 29 16·5	24 30·49		
12 7									+1·97	
				+3·29					+2·69	+2·81
13 10	17 58 27	10 30 15·4	+1 5·71							
				+2·34						
14 19	3 16 53	19 43 12·2	+1 8·96						+2·69	+2·55
				+2·24					+1·96	
15 19										
16 4					5 10 25·0	+1 11·99	12 48 28·5	24 30·57	+1·96	
16 7										
				+2·24					+1·88	+1·96
17 10	18 7 38	10 23 37·0	+1 14·68							
				+1·58						
18 19	3 31 31	19 42 1·4	+1 16·87						+1·88	+1·79
				+3·18					+1·96	
19 19										
20 9					10 58 35·4	+1 21·25	18 53 25·5	24 32·20	+1·96	
21 7										
				+3·18					+4·02	+4·42
22 10	18 57 40	10 53 46·2	+1 26·61							
				+2·25						
18 19	3 31 31	19 42 1·4	+1 16·87							
				+3·18					+1·88	+1·79
19 19									+1·96	
21 5					5 46 55·4	+1 23·37	13 44 51·5	24 32·79		
21 7									+1·96	
				+3·18					+4·02	+4·42
22 10	18 57 40	10 53 46·2	+1 26·61							
				+2·25						
22 19	3 47 38	19 42 17·0	+1 27·44							
				+2·99					+4·02	+3·57
23 19									+2·25	
24 3					3 44 40·6	+1 31·16	11 54 13·5	24 30·27		
24 7									+2·25	
				+2·99					+2·33	+2·47
25 10				+2·25						
25 19	3 51 58	19 34 43·8	+1 35·78						+2·33	+2·17
26 19									+2·25	
27 3					4 19 44·2	+1 39·52	12 41 15·5	24 31·64		

Concluded Longitude of Kingstown from Greenwich = 24m 30s·92 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *d*.

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
June d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
26 19	1 31 8	19 6 31·5	+2 48·24							
				+2·65						+2·45
27 19									+4·17	
27 22					23 44 52·5	+2 51·78	6 13 4·0	24 31·93		
									+4·17	
28 7				+2·65					+2·95	+2·83
29 10	17 36 33	11 1 21·37	+2 56·11							
				+4·17						
30 19	1 50 12	19 9 39·37	+3 1·70						+2·95	+3·09
July				+2·87						
1 19									+4·08	
2 1					3 19 52·63	+3 5·85	10 4 36·0	24 31·30		
									+4·08	
2 7				+2·87					+3·20	+2·68
3 10	17 33 51	10 42 46·5	+3 9·95							
				+3·99						
3 19	2 25 9	19 32 36·37	+3 11·43						+3·20	+3·79
				+3·78						
4 19									+3·70	
5 2					2 56 8·63	+3 16·33	9 52 45·0	24 31·61		
									+3·70	
5 7				+3·78					+3·88	+3·77
6 10	17 44 50	10 41 48·0	+3 21·35							
				+3·40						
7 19	2 51 2	19 42 31·5	+3 26·03						+3·88	+4·00
				+3·97						
8 19									+5·00	
9 3					4 9 36·0	+3 31·71	11 22 21·5	24 31·56		
									+5·00	
9 7				+3·97					+3·88	+3·94
10 10	17 50 58	10 32 0·37	+3 36·96							
				+6·60						
10 19	3 0 6	19 39 36·37	+3 39·48						+3·88	+3·81
				+3·95						
11 19									+5·26	
12 3					4 6 14·63	+3 45·18	11 30 58·5	24 31·68		
									+5·26	
12 7				+3·95					+3·84	+4·07
13 10	18 0 0	10 29 3·37	+3 50·48							
				+3·91						
14 19	3 18 31	19 42 3·0	+3 55·89							
				+3·67					+3·84	+3·58
15 19									+3·63	
16 4					5 9 15·38	+4 0·99	12 50 7·0	24 31·72		
									+3·63	
16 7				+3·67					+3·55	+3·75
17 10	18 9 4	10 22 12·0	+4 5·46							
				+3·34						
18 19	3 32 35	19 40 12·0	+4 10·09						+3·55	+3·32
				+4·12						
19 19									+3·13	

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *d.—concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
20 9					11 7 27·75	+4 16·18	19 5 14·5	24 32·41		
21 7									+3·13	
22 10	18 59 3	10 52 12·0	+4 23·58	+4·12					+5·22	+4·83
				+4·55						
18 19	3 32 35	19 40 12·0	+4 10·09							
19 19				+4·12					+3·55	+3·32
21 5					5 46 24·38	+4 19·13	13 47 16·5	24 32·92	+3·13	
21 7									+3·13	
22 10	18 59 3	10 52 12·0	+4 23·58	+4·12					+5·22	+4·83
22 19	3 48 40	19 40 21·0	+4 25·26	+4·55						
23 19				+5·50					+5·22	+5·66
24 3					3 44 12·75	+4 32·23	11 56 46·0	24 31·41	+4·55	
24 7									+4·55	
25 10				+5·50					+5·41	+5·36
25 19	3 53 47	19 33 27·37	+4 40·91	+4·55						
26 19									+5·41	+5·47
27 3					4 18 6·38	+4 48·02	12 42 46·5	24 31·56	+4·55	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·74 West.

CHRONOMETER *e.*

June 26. 19	1 34 10	19 11 2·25	+1 18·99							
27 19				−0·64						−0·81
27 22					23 53 30·75	+1 18·40	6 20 10·5	24 31·46	+0·11	
28 7									+0·11	
29 10	17 39 16	11 5 42·37	+1 17·68	−0·64					−0·59	−0·49
30 19	1 51 46	19 12 57·0	+1 17·82	+0·11						
July 1 19				−0·99					−0·59	−0·70
2 1					3 24 54·0	+1 16·55	10 7 49·0	24 30·89	−0·68	
2 7									−0·68	
				−0·99					−2·90	−1·24

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *e.*—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 35 56	10 46 45·75	+1 15·35							
				−1·46						
3 19	2 26 40	19 36 3·75	+1 14·81							
				−2·41					−2·90	−4·76
4 19									−1·39	
5 2					3 4 42·38	+1 11·93	9 59 13·5	24 33·53		
5 7									−1·39	
				−2·41					−0·83	−0·32
6 10	17 46 21	10 45 31·12	+1 8·98							
				−1·31						
7 19	2 52 34	19 46 22·12	+1 7·17							
				−2·13					−0·83	−1·41
8 19									−1·60	
9 3					4 15 26·63	+1 4·41	11 25 46·5	24 30·43		
9 7									−1·60	
				−2·13					−2·18	−2·77
10 10	17 53 38	10 37 15·05	+1 1·85							
				−1·89						
10 19	3 1 32	19 43 40·5	+1 1·12							
				−2·35					−2·18	−1·51
11 19									−1·68	
12 3					4 12 27·75	+0 58·12	11 34 26·5	24 30·31		
12 7									−1·68	
				−2·35					−2·43	−3·10
13 10	18 1 2	10 33 0·37	+0 55·31							
				−1·47						
14 19	3 19 56	19 46 30·37	+0 53·28							
				−1·98					−2·43	−1·68
15 19									−1·91	
16 4					5 16 21·38	+0 50·55	12 54 4·0	24 30·92		
16 7									−1·91	
				−1·98					−1·66	−2·25
17 10	18 10 59	10 27 24·0	+0 48·14							
				−2·34						
18 19	3 33 49	19 44 51·0	+0 44·89							
				−1·63					−1·66	−1·00
19 19									−1·84	
20 9					11 20 33·0	+0 42·06	19 14 49·0	24 30·60		
21 7									−1·84	
				−1·63					−1·20	−2·19
22 10	19 0 4	10 56 57·75	+0 38·67							
				−1·49						
18 19	3 33 49	19 44 51·0	+0 44·89							
				−1·63					−1·66	−1·00
19 19									−1·84	
21 5					5 52 35·63	+0 40·74	13 49 52·0	24 30·70		
21 7									−1·84	
				−1·63					−1·20	−2·19
22 10	19 0 4	10 56 57·75	+0 38·67							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *e.*—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 49 32	19 45 0·0	+0 38·12	−1·49						
				+0·43					−1·20	−0·09
23 19									−1·49	
24 3					3 49 13·13	+0 37·96	11 57 52·0	24 31·69		
24 7									−1·49	
25 10				+0·43					+0·49	+0·89
25 19	3 54 47	19 38 30·37	+0 37·75	−1·49						
26 19									+0·49	+0·04
27 3					4 24 30·0	+0 37·59	12 45 0·0	24 31·61	−1·49	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·19 West.

CHRONOMETER *f.*

June 26 19	1 35 13	19 15 24·0	−1 59·92							
				−1·34						−0·76
27 19									−1·09	
27 22					0 1 12·0	−2 1·46	6 24 33·5	24 30·55	−1·09	
28 7				−1·34					−1·79	−1·86
29 10	17 41 49	11 11 36·0	−2 3·37	−1·09						
30 19	1 53 30	19 18 3·37	−2 4·84	−2·10					−1·79	−1·72
July 1 19									−1·63	
2 1					3 32 56·63	−2 7·51	10 12 28·5	24 30·71	−1·63	
2 7				−2·10					−1·90	−2·44
3 10	17 37 30	10 51 45·0	−2 10·15	−2·17						
3 19	2 27 32	19 40 21·37	−2 10·96	−1·42					−1·90	−1·29
4 19									−2·32	
5 2					3 11 12·38	−2 13·06	10 2 21·5	24 31·04	−2·32	
5 7				−1·42					−1·43	−1·53
6 10	17 47 59	10 50 33·0	−2 15·16	−2·46						
7 19	2 54 33	19 51 46·5	−2 18·54	−1·16					−1·43	−1·31
8 19									−2·61	
9 3					4 28 6·0	−2 20·48	11 35 1·5	24 31·43	−2·61	
9 7				−1·16					−1·02	−1·02
10 10	17 52 29	10 39 30·37	−2 22·29	−2·76						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *e.*—*continued.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
3 10	17 35 56	10 46 45·75	+1 15·35							
				−1·46						
3 19	2 26 40	19 36 3·75	+1 14·81							
				−2·41					−2·90	−4·76
4 19									−1·39	
5 2					3 4 42·38	+1 11·93	9 59 13·5	24 33·53		
									−1·39	
5 7				−2·41					−0·83	−0·32
6 10	17 46 21	10 45 31·12	+1 8·98							
				−1·31						
7 19	2 52 34	19 46 22·12	+1 7·17						−0·83	−1·41
				−2·13						
8 19									−1·60	
9 3					4 15 26·63	+1 4·41	11 25 46·5	24 30·43		
									−1·60	
9 7				−2·13					−2·18	−2·77
10 10	17 53 38	10 37 15·05	+1 1·85							
				−1·89						
10 19	3 1 32	19 43 40·5	+1 1·12						−2·18	−1·51
				−2·35						
11 19									−1·68	
12 3					4 12 27·75	+0 58·12	11 34 26·5	24 30·31		
									−1·68	
12 7				−2·35					−2·43	−3·10
13 10	18 1 2	10 33 0·37	+0 55·31							
				−1·47						
14 19	3 19 56	19 46 30·37	+0 53·28						−2·43	−1·68
				−1·98						
15 19									−1·91	
16 4					5 16 21·38	+0 50·55	12 54 4·0	24 30·92		
									−1·91	
16 7				−1·98					−1·66	−2·25
17 10	18 10 59	10 27 24·0	+0 48·14							
				−2·34						
18 19	3 33 49	19 44 51·0	+0 44·89						−1·66	−1·00
				−1·63						
19 19									−1·84	
20 9					11 20 33·0	+0 42·06	19 14 49·0	24 30·60		
									−1·84	
21 7				−1·63					−1·20	−2·19
22 10	19 0 4	10 56 57·75	+0 38·67							
				−1·49						
18 19	3 33 49	19 44 51·0	+0 44·89							
				−1·63					−1·66	−1·00
19 19									−1·84	
21 5					5 52 35·63	+0 40·74	13 49 52·0	24 30·70		
									−1·84	
21 7				−1·63					−1·20	−2·19
22 10	19 0 4	10 56 57·75	+0 38·67							

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *e.*—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					Chronometer's Adopted Losing Rate.
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
22 19	3 49 32	19 45 0·0	+0 38·12	−1·49						
23 19				+0·43					−1·20	−0·09
24 3					3 49 13·13	+0 37·96	11 57 52·0	24 31·69	−1·49	
24 7									−1·49	
25 10				+0·43					+0·49	+0·89
25 19	3 54 47	19 38 30·37	+0 37·75	−1·49						
26 19									+0·49	+0·04
27 3					4 24 30·0	+0 37·59	12 45 0·0	24 31·61	−1·49	

Concluded Longitude of Kingstown from Greenwich = 24m 31s·19 West.

CHRONOMETER *f.*

June 26 19	1 35 13	19 15 24·0	−1 59·92							
27 19				−1·34						−0·76
27 22					0 1 12·0	−2 1·46	6 24 33·5	24 30·55	−1·09	
28 7									−1·09	
29 10	17 41 49	11 11 36·0	−2 3·37	−1·34					−1·79	−1·86
30 19	1 53 30	19 18 3·37	−2 4·84	−1·09						
July 1 19				−2·10					−1·79	−1·72
2 1					3 32 56·63	−2 7·51	10 12 28·5	24 30·71	−1·63	
2 7									−1·63	
3 10	17 37 30	10 51 45·0	−2 10·15	−2·10					−1·90	−2·44
3 19	2 27 32	19 40 21·37	−2 10·96	−2·17						
4 19				−1·42					−1·90	−1·29
5 2					3 11 12·38	−2 13·06	10 2 21·5	24 31·04	−2·32	
5 7									−2·32	
6 10	17 47 59	10 50 33·0	−2 15·16	−1·42					−1·43	−1·53
7 19	2 54 33	19 51 46·5	−2 18·54	−2·46						
8 19				−1·16					−1·43	−1·31
9 3					4 28 6·0	−2 20·48	11 35 1·5	24 31·43	−2·61	
9 7									−2·61	
10 10	17 52 29	10 39 30·37	−2 22·29	−1·16					−1·02	−1·02
				−2·76						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF KINGSTOWN FROM GREENWICH.

CHRONOMETER *f.*—*concluded.*

Comparisons at Greenwich.					Comparisons at Kingstown.					
Approximate Solar Time, 1844.	Time by Greenwich Transit Clock.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's Apparent Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by $\frac{1}{2}\Sigma$.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
July d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
10 19	3 5 4	19 50 36·37	−2 23·34							
				−1·47					−1·02	−1·02
11 19									−2·87	
12 3					4 19 21·0	−2 25·68	11 37 56·0	24 30·82		
12 7									−2·87	
				−1·47					−2·07	−1·87
13 10	18 2 6	10 37 27·37	−2 27·88							
				−2·98						
14 19	3 21 2	19 51 1·5	−2 32·01							
				−1·19					−2·07	−2·29
15 19									−2·66	
16 4					5 21 59·63	−2 34·05	12 56 16·5	24 32·43		
16 7									−2·66	
				−1·19					−1·30	−0·21
17 10	18 12 18	10 32 6·75	−2 35·83							
				−2·33						
18 19	3 35 8	19 49 33·75	−2 39·07							
				−2·60					−1·30	−2·52
19 19									−2·38	
20 9					11 29 57·75	−2 43·22	19 20 49·0	24 31·05		
21 7									−2·38	
				−2·60					−2·17	−2·67
22 10	19 1 57	11 2 17·25	−2 48·14							
				−3·53						
18 19	3 35 8	19 49 33·75	−2 39·07							
				−2·60					−1·30	−2·52
19 19									−2·38	
21 5					5 59 8·75	−2 45·12	13 52 59·5	24 30·98		
21 7									−2·38	
				−2·60					−2·17	−2·67
22 10	19 1 57	11 2 17·25	−2 48·14							
				−3·53						
22 19	3 50 35	19 49 30·37	−2 49·44							
				−1·56					−2·17	−1·61
23 19									−3·53	
24 3					3 56 40·13	−2 52·29	12 1 50·0	24 31·09		
24 7									−3·53	
				−1·56					−1·74	−1·52
25 10										
				−3·53						
25 19	3 56 2	19 43 18·75	−2 55·83						−1·74	−1·99
26 19									−3·53	
27 3					4 29 36·0	−2 58·70	12 46 30·0	24 31·56		

Concluded Longitude of Kingstown from Greenwich = 24m 31s·05 West.

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The following Table contains the Results from all the Chronometers.

Reference to Chronometer.	Longitude of Kingstown West of Greenwich.	Sum of Squares of Changes of Rate.	Weight of Result.
	m s		
A	24 31·18	10·3739	96
B	24 31·02	15·4183	65
C	24 31·22	26·9721	37
D	24 31·16	26·9183	37
E	24 31·17	7·6459	131
F	24 31·31	29·8487	33
G	24 30·91	16·8947	59
H	24 31·05	18·4051	54
I	24 31·10	18·0763	55
J	24 31·18	5·5568	180
K	24 30·52	9·9624	100
L	24 31·28	12·0563	66
M	24 31·38	18·3417	54
N	24 30·65	15·6931	64
O	24 31·36	44·9166	22
P	24 30·90	3·1271	320
Q	24 30·68	49·3369	15
R	24 30·45	14·0394	71
S	24 30·67	161·9213	6
T	24 31·07	11·5482	87
U	24 31·38	18·2130	55
W	24 30·97	13·2794	75
X	24 31·12	4·9861	200
Y	24 30·93	26·3868	38
Z	24 30·80	33·0551	30
a	24 30·39	15·8246	63
b	24 30·92	26·7629	37
d	24 31·74	5·2786	189
e	24 31·19	51·1083	19
f	24 31·05	15·1971	66

The sum of weights is 2324

The result for the Longitude of Kingstown temporary Observatory, West of Greenwich Observatory, is ..... $24^m\ 31^s{\cdot}062$

The probable error of this determination, as depending on the unsteadiness of rate of the travelling chronometers, is ..... $\pm\ 0^s{\cdot}0188$

It must be borne in mind that this determination is based upon Kingstown transits as observed by Mr. Hind, and Greenwich transits as observed by Mr. Henry; and that no correction is yet applied for personal equation.

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XII. — *Comparisons and Calculations for the Longitude of Valentia, as determined with reference to Kingstown.*

The chronometers arrived at Dublin by the morning mail, and were brought to Kingstown shortly after eight o'clock. They were not compared immediately, but about two o'clock in the afternoon (sometimes earlier and sometimes later). They left Kingstown at five or six o'clock in the evening. They arrived at Valentia after midnight on the following day, and were then not immediately compared (with the exception of two instances only, of which however no notice is taken here), but were compared at one or two o'clock on the next day. Then they left Valentia late in the evening, and arrived at Kingstown on the next morning but one. The hour of comparison at Valentia was, on the average, a little later than that at Kingstown: the difference being an hour and forty or fifty minutes.

As the same journey was performed, in the same manner, in going backwards and forwards, it appears reasonable to suppose that the times corresponding to the stationary rates and those corresponding to the travelling rates were almost in the same proportion in the two journeys, and thus that the stationary and travelling rates may be fairly blended into one mixed rate. And, as the intervals between the Valentia and Kingstown comparisons are so nearly equal to those between the Kingstown and Valentia comparisons, they may be assumed as equal in the operations for application of the method of minimum squares.

The process then becomes exactly the same as that which is described in Section VIII. And as the time through which one rate is used is 48^h nearly, and the number of changes is 19, the probable error of the determination of longitude from the combination of the results of all the chronometers, A, B, &c., with the weights, W_A, W_B, &c.

$$\left(\text{where } W_A = \frac{1000}{\text{sum of minimum squares for } A}, \text{ \&c.}\right)$$

will be

$$\frac{\pm 0{\cdot}6745}{19} \times \sqrt{\frac{1000}{W_A + W_B + \text{\&c.}}}.$$

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The chronometer S appears to have tripped between August 23 and 25; and the two series of comparisons, ending with August 23 and beginning with August 25, are treated without connexion, and the sum of the squares is multiplied by 1·6. The chronometer d ran down at an early stage of the operations, and the first rates being rejected, the sum of squares for the others is multiplied by 1·5.

The chronometer-time at comparison is occasionally altered in the second decimal for the same reason as in the last section.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer A.

Approximate Solar Time, 1844.	Comparisons at Kingstown: Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Valentia: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	12 56 48·0	4 0 44·8	−23 31·03				(Chron. 2306.)			
				+0·10						+0·33
7 4				+0·10	1 32 20·0	−23 30·85	9 56 17·0	16 51·64		
9 0	9 15 33·0	0 4 23·2	−23 30·66						−0·02	−0·13
				+0·31			(Chron. 2306.)		−0·02	
11 3					1 25 50·0	−23 30·03	10 5 23·0	16 52·52		+0·09
				+0·31					+0·66	+0·53
13 0	9 43 46·0	0 16 47·6	−23 29·44				(Transit Clock)			
				+0·68	0 2 32·0	−23 28·07	8 57 31·0	16 51·86	+0·66	+0·79
15 2									+0·55	+0·57
				+0·68						
17 1	10 34 58·0	0 52 6·4	−23 26·69						+0·55	+0·53
				+0·55	2 5 14·8	−23 25·55	11 16 14·0	16 52·11		
19 3				+0·55					+0·60	+0·57
21 1	11 37 24·5	1 38 40·8	−23 24·47							
				+0·78	0 50 12·0	−23 22·93	10 16 39·0	16 52·34	+0·60	+0·63
23 2				+0·78					+0·74	+0·93
25 2	12 43 57·5	2 29 19·2	−23 21·34							
				+0·70	2 22 10·0	−23 19·93	12 5 33·0	16 52·34	+0·74	+0·55
27 3				+0·70					+0·82	+0·85
29 0	10 39 41·5	0 9 39·6	−23 18·60							
				+1·05	2 11 41·2	−23 16·39	12 10 44·0	16 52·61	+0·82	+0·79
31 3									+1·17	+1·31
Sep.				+1·05						
2 0	9 57 11·5	23 11 32·8	−23 14·45						+1·17	+1·03
				+0·89	2 39 31·2	−23 12·53	12 54 21·0	16 51·76		
4 3				+0·89					+0·88	+0·75
6 0	11 3 9·0	0 1 36·0	−23 10·86						+0·88	+1·01
				+0·74	0 42 17·18	−23 9·34	11 14 30·0	16 51·51		
8 3				+0·74					+0·42	+0·47
10 1	12 25 0·5	1 7 31·2	−23 7·84						+0·42	+0·37
				+0·36	3 8 56·0	−23 7·09	13 56 45·0	16 52·03		
12 4				+0·36						+0·35
14 0	10 49 13·5	23 16 18·0	−23 6·44							

Concluded Longitude of Valentia from Kingstown = 16m 52s·06 West.

Chronometer B.

Aug.										
5 4	12 58 0·0	3 53 46·4	−15 20·82							
				+5·37			(Chron. 2306.)			+5·28
7 4				+5·37	4 10 54·4	−15 9·93	12 43 39·0	16 52·11	+5·26	+5·46
9 0	9 18 40·0	23 58 59·2	−15 0·17				(Chron. 2306.)		+5·26	
				+5·48	1 11 32·0	−14 48·85	9 59 45·0	16 52·79		+5·06
11 3				+5·48					+5·66	+5·90
13 0	9 46 18·5	0 10 28·4	−14 38·16				(Transit Clock)			
				+5·50	23 55 58·0	−14 27·11	8 59 58·0	16 52·22	+5·66	+5·42
15 2				+5·50					+5·89	+5·58
17 1	10 40 58·5	0 48 55·2	−14 15·97							
				+5·87	2 2 20·38	−14 3·85	11 22 43·0	16 51·46	+5·89	+6·20
19 3				+5·87					+6·08	+5·54
21 1	11 38 50·5	1 30 34·4	−13 52·30						+6·08	+6·62
				+6·47	0 44 44·4	−13 39·48	10 20 56·0	16 51·89		
23 2				+6·47					+5·92	+6·32
25 2	12 45 16·5	2 20 42·8	−13 26·16						+5·92	+5·52
				+5·55						

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER B.—*concluded.*

Comparisons at Kingstown.					Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3					2 16 18·4	−13 15·03	12 9 47·0	16 52·32		
				+5·55					+5·60	+5·58
29 0	10 41 23·5	0 1 7·2	−13 4·48							
				+5·64					+5·60	+5·62
31 3					2 4 39·6	−12 52·68	12 14 7·0	16 52·27		
Sep.				+5·64					+5·74	+5·66
2 0	9 58 28·0	23 2 16·8	−12 42·16							
				+5·71					+5·74	+5·82
4 3					2 32 23·2	−12 29·86	12 57 56·0	16 52·02		
				+5·71					+5·69	+5·60
6 0	11 4 47·0	23 52 22·0	−12 19·12							
				+5·63					+5·69	+5·78
8 3					0 37 0·0	−12 7·62	11 20 15·0	16 51·98		
				+5·63					+5·40	+5·48
10 1	12 26 43·5	0 58 2·4	−11 56·32							
				+5·45					+5·40	+5·32
12 4					2 59 36·0	−11 44·92	13 58 47·0	16 52·54		
				+5·45						+5·58
14 0	10 52 15·5	23 7 48·0	−11 34·94							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·13 West.

CHRONOMETER C.

Aug.										
5 4	12 59 13·0	3 58 36·8	−18 58·42							
				+2·12						+2·16
7 4					4 16 38·4	−18 54·11	(Chron. 2306) 12 45 39·5	16 51·75		
				+2·12					+2·22	+2·08
9 0	9 20 21·0	0 4 30·0	−18 50·25							
				+2·89			(Chron. 2306.)		+2·22	+2·36
11 3					1 25 22·0	−18 44·27	10 9 41·0	16 52·98		
				+2·89					+3·53	+3·42
13 0	9 48 42·0	0 16 52·0	−18 38·65							
				+3·65			(TransitClock)		+3·53	+3·64
15 2					0 2 37·57	−18 31·30	9 2 34·0	16 52·02		
				+3·65					+3·41	+3·66
17 1	10 46 43·5	0 58 47·2	−18 23·91							
				+3·22					+3·41	+3·16
19 3					2 10 34·8	−18 17·26	11 26 44·0	16 52·10		
				+3·22					+3·35	+3·28
21 1	11 40 55·0	1 36 57·2	−18 10·94							
				+3·51					+3·35	+3·42
23 2					0 55 54·0	−18 3·97	10 27 42·0	16 52·11		
				+3·51					+3·20	+3·60
25 2	12 47 5·0	2 27 1·6	−17 56·75							
				+3·08					+3·20	+2·80
27 3					2 26 49·2	−17 50·55	12 15 43·0	16 52·55		
				+3·08					+3·50	+3·36
29 0	10 43 54·5	0 8 18·0	−17 44·68							
				+3·85					+3·50	+3·64
31 3					2 14 8·0	−17 36·60	12 18 52·0	16 52·53		
				+3·85					+3·80	+4·06
Sep.										
2 0	10 0 51·5	23 9 27·2	−17 29·45							
				+3·28					+3·80	+3·54
4 3					2 42 10·38	−17 22·33	13 2 52·0	16 51·53		
				+3·28					+3·37	+3·02
6 0	11 6 45·5	23 59 17·2	−17 16·15							
				+3·33					+3·37	+3·72
8 3					0 43 42·8	−17 9·34	11 21 57·0	16 51·33		
				+3·33					+3·17	+2·94
10 1	12 28 37·5	1 5 2·4	−17 2·63							
				+3·05					+3·17	+3·40
12 4					3 6 18·0	−16 56·26	14 0 19·0	16 51·45		
				+3·05						+2·70
14 0	10 53 21·5	23 14 9·6	−16 50·72							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·00 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer D.

Comparisons at Kingstown.						Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.		Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s		h m s	m s	h m s	m s	s	s
5. 4	13 0 23·0	4 2 12·8	−21 24·62								
				+4·05				(Chron. 2306.)			+4·24
7 4						4 21 42·0	−21 16·37	12 48 21·0	16 52·03		
				+4·05						+3·77	+3·86
9 0	9 21 22·0	0 7 49·6	−21 9·02								
				+4·03				(Chron. 2306.)		+3·77	+3·68
11 3						1 36 52·0	−21 0·64	10 18 56·0	16 53·10		
				+4·03						+4·53	+4·38
13 0	9 49 46·0	0 20 10·0	−20 52·82								
				+4·56				(TransitClock)		+4·53	+4·68
15 2						0 9 44·34	−20 43·62	9 7 29·0	16 52·26		
				+4·56						+4·60	+4·44
17 1	10 49 3·0	1 3 16·8	−20 34·39								
				+4·75						+4·60	+4·76
19 3						2 21 38·0	−20 24·59	11 35 41·0	16 52·43		
				+4·75						+4·66	+4·74
21 1	11 43 19·0	1 41 25·2	−20 15·33								
				+4·37						+4·66	+4·58
23 2						1 0 3·2	−20 6·63	10 29 49·0	16 51·98		
				+4·37						+4·48	+4·16
25 2	12 49 36·5	2 31 33·6	−19 57·67								
				+5·06						+4·48	+4·80
27 3						2 31 48·0	−19 47·49	12 18 45·0	16 52·92		
				+5·06						+5·10	+5·32
29 0	10 45 11·5	0 11 28·0	−19 37·89								
				+5·17						+5·10	+4·88
31 3						2 20 13·2	−19 26·99	12 23 7·0	16 53·02		
				+5·17						+5·40	+5·46
Sep. 2 0	10 2 11·0	23 12 34·4	−19 17·36								
				+5·21						+5·40	+5·34
4 3						2 48 58·0	−19 6·10	13 7 56·0	16 52·21		
				+5·21						+4·99	+5·08
6 0	11 8 36·0	0 2 47·6	−18 56·35								
				+4·86						+4·99	+4·90
8 3						0 55 21·2	−18 46·39	11 31 59·0	16 52·32		
				+4·86						+4·85	+4·82
10 1	12 31 23·5	1 9 22·0	−18 36·68								
				+4·82						+4·85	+4·88
12 4						3 20 51·98	−18 26·56	14 13 24·0	16 52·26		
				+4·82							+4·76
14 0	10 56 2·5	23 18 17·2	−18 17·76								

Concluded Longitude of Valentia from Kingstown = 16m 52s·42 West.

Chronometer E.

Aug. 5 4	13 2 43·5	4 7 58·4	−24 50·10								
				+0·52				(Chron. 2306.)			+0·33
7 4						4 26 10·0	−24 49·04	12 49 16·0	16 52·51		
				+0·52						+0·64	+0·71
9 0	9 23 6·0	0 13 12·4	−24 48·10								
				+0·65				(Chron. 2306.)		+0·64	+0·57
11 3						1 45 26·0	−24 46·74	10 23 45·5	16 52·29		
				+0·65						+1·04	+0·73
13 0	9 51 56·5	0 26 12·8	−24 45·48								
				+1·09				(TransitClock)		+1·04	+1·35
15 2						0 18 25·62	−24 43·28	9 12 12·0	16 51·66		
				+1·09						+1·45	+0·83
17 1	10 50 12·5	1 8 32·8	−24 41·08								
				+1·83						+1·45	+2·07
19 3						2 28 9·6	−24 37·29	11 38 1·0	16 51·71		
				+1·83						+1·74	+1·59
21 1	11 44 28·0	1 46 52·4	−24 33·72								
				+1·88						+1·74	+1·89
23 2						1 14 52·0	−24 29·97	10 40 16·0	16 52·14		
				+1·88						+1·21	+1·87
25 2	12 51 11·5	2 37 36·8	−24 26·13								
				+0·60						+1·21	+0·55

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER E.—*concluded.*

Comparisons at Kingstown.						Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ☽ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.		Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s		h m s	m s	h m s	m s	s	s
27 3						2 40 1·2	−24 24·92	12 22 22·0	16 52·28		
				+0·60						+0·41	+0·65
29 0	10 47 3·5	0 18 5·6	−24 23·80								
				−0·03		2 27 20·38	−24 23·85	12 25 19·0	16 51·71	+0·41	+0·17
31 3											
Sep.				−0·03						−0·18	−0·23
2 0	10 4 50·5	23 20 20·0	−24 23·90								
				−0·06						−0·18	−0·13
4 3						2 57 50·4	−24 24·04	13 11 31·0	16 52·25		
				−0·06						−0·14	+0·01
6 0	11 10 30·5	0 10 9·6	−24 24·16								
				−0·05						−0·14	−0·29
8 3						1 2 52·0	−24 24·27	11 33 52·0	16 52·55		
				−0·05						+0·14	+0·19
10 1	12 33 10·5	1 16 56·4	−24 24·37								
				+0·05						+0·14	+0·09
12 4						3 34 29·18	−24 24·26	14 21 5·0	16 52·00		
				+0·05							+0·01
14 0	10 57 56·0	23 26 16·8	−24 24·17								

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·12 West.

CHRONOMETER F.

Aug.											
5 4	13 4 30·5	4 7 21·6	−22 26·59								
				+1·56				(Chron. 2306.)			+1·93
7 4						4 25 4·8	−22 23·41	12 50 37·5	16 51·66		
				+1·56						+0·82	+1·19
9 0	9 24 45·0	0 12 23·6	−22 20·58					(Chron 2306.)			
				+0·87						+0·82	+0·45
11 3						1 48 24·0	−22 18·76	10 29 11·5	16 53·13		
				+0·87						+1·10	+1·29
13 0	9 54 20·5	0 26 8·0	−22 17·07								
				+0·72				(TransitClock)		+1·10	+0·91
15 2						0 27 38·36	−22 15·61	9 23 54·0	16 51·95		
				+0·72						+0·97	+0·53
17 1	10 52 29·0	1 8 22·0	−22 14·15								
				+1·17						+0·97	+1·41
19 3						2 33 10·0	−22 11·73	11 45 28·0	16 51·87		
				+1·17						+1·03	+0·93
21 1	11 46 33·0	1 46 32·8	−22 9·45								
				+0·99						+1·03	+1·13
23 2						1 15 2·0	−22 7·47	10 42 49·0	16 52·06		
				+0·99						+0·93	+0·85
25 2	12 53 8·5	2 37 12·8	−22 5·45								
				+1·12						+0·93	+1·01
27 3						2 41 11·2	−22 3·19	12 25 54·0	16 52·56		
				+1·12						+1·15	+1·23
29 0	10 48 50·5	0 17 29·6	−22 1·09								
				+1·29						+1·15	+1·07
31 3						2 29 45·2	−21 58·39	12 30 9·0	16 52·76		
				+1·29						+1·17	+1·51
Sep.											
2 0	10 6 5·0	23 19 6·4	−21 56·00								
				+0·98						+1·17	+0·83
4 3						2 58 46·0	−21 53·87	13 14 57·0	16 52·57		
				+0·98						+1·15	+1·13
6 0	11 12 12·5	0 9 19·2	−21 52·04								
				+1·26						+1·15	+1·17
8 3						1 1 4·0	−21 49·46	11 34 39·0	16 52·49		
				+1·26						+1·40	+1·35
10 1	12 34 45·0	1 15 53·2	−21 46·94								
				+1·19						+1·40	+1·45
12 4						3 44 48·0	−21 44·42	14 34 6·0	16 51·78		
				+1·19							+0·93
14 0	10 59 53·0	23 25 31·6	−21 42·28								

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·32 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer G.

Comparisons at Kingstown.					Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 6 19·0	4 8 26·8	−21 43·59							
				+1·86			(Chron. 2306.)			+1·81
7 4					4 26 36·8	−21 39·81	12 52 53·0	16 52·13		
				+1·86					+1·80	+1·91
9 0	9 26 23·0	0 13 17·2	−21 36·44				(Chron. 2306.)		+1·80	+1·69
				+2·24	2 2 58·0	−21 31·75	10 44 35·0	16 53·16		
11 3									+2·84	+2·79
				+2·24			(Transit Clock)			
13 0	9 55 25·5	0 26 23·2	−21 27·45						+2·84	+2·89
				+2·95	0 30 0·0	−21 21·51	9 27 10·0	16 52·21		
15 2									+3·10	+3·01
				+2·95						
17 1	10 54 25·5	1 9 19·6	−21 15·57						+3·10	+3·19
				+3·04	2 33 33·2	−21 9·25	11 46 54·0	16 51·80		
19 3									+2·76	+2·89
				+3·04						
21 1	11 48 53·5	1 47 46·8	−21 3·34						+2·76	+2·63
				+2·79	1 17 47·98	−20 57·76	10 46 45·0	16 52. 39		
23 2									+2·65	+2·95
				+2·79						
25 2	12 55 35·5	2 38 26·0	−20 52·05						+2·65	+2·35
				+2·61	2 45 2·0	−20 46·78	12 31 2·0	16 52·62		
27 3									+3·20	+2·87
				+2·61						
29 0	10 51 2·5	0 18 22·0	−20 41·85						+3·20	+3·53
				+3·81	2 31 21·2	−20 33·82	12 33 10·0	16 52·82		
31 3									+4·05	+4·09
				+3·81						
Sep. 2 0	10 8 11·0	23 19 42·8	−20 26·75						+4·05	+4·01
				+3·93	3 0 26·4	−20 18·21	13 18 14·0	16 52·17		
4 3									+4·10	+3·85
				+3·93						
6 0	11 14 10·0	0 9 35·2	−20 10·86						+4·10	+4·35
				+3·92	1 1 10·0	−20 2·79	11 36 33·0	16 51·47		
8 3									+3·72	+3·49
				+3·92						
10 1	12 36 40·5	1 15 56·4	−19 54·94						+3·72	+3·95
				+3·60	3 43 51·6	−19 47·31	14 35 7·0	16 51·65		
12 4										+3·25
				+3·60						
14 0	11 1 40·0	23 25 16·8	−19 40·77							

Concluded Longitude of Valentia from Kingstown = $16^m\ 52^s{\cdot}16$ West.

Chronometer H.

Aug.										
5 4	13 9 42·5	4 1 36·4	−11 30·25							
				+6·84			(Chron. 2306.)			+6·86
7 4					4 17 44·4	−11 16·43	12 54 24·5	16 51·86		
				+6·84					+6·78	+6·82
9 0	9 36 21·5	0 12 41·6	−11 3·98				(Chron. 2306.)		+6·78	+6·74
				+6·42	1 58 45·92	−10 50·55	10 51 7·0	16 51·33		
11 3									+6·10	+6·10
				+6·42			(Transit Clock)			
13 0	9 57 31·5	0 17 39·6	−10 38·19						+6·10	+6·10
				+6·35	0 22 21·6	−10 25·39	9 30 28·0	16 52·47		
15 2									+6·75	+6·60
				+6·35						
17 1	10 56 26·0	1 0 16·8	−10 12·60						+6·75	+6·90
				+6·38	2 29 23·2	− 9 59·37	11 53 56·0	16 50·80		
19 3									+5·95	+5·86
				+6·38						
21 1	11 50 23·0	1 37 59·6	− 9 46·88						+5·95	+6·04
				+6·36	1 9 8·0	− 9 34·25	10 49 29·0	16 52·35		
23 2									+6·80	+6·68
				+6·36						
25 2	12 57 23·0	2 28 42·4	− 9 21·23							
				+7·09					+6·80	+6·92

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER H.—*concluded.*

Comparisons at Kingstown.						Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.		Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s			h m s	m s	h m s	m s	s	s
27 3						2 36 3·2	— 9 6·97	12 33 44·0	16 52·07		
				+7·09						+7·00	+7·26
29 0	10 52 33·0	0 8 4·0	— 8 53·60								
				+6·47						+7·00	+6·74
31 3						2 23 18·0	— 8 39·98	12 37 3·0	16 51·09		
				+6·47						+6·21	+6·20
Sep. 2 0	10 11 15·5	23 10 48·0	— 8 27·96								
				+6·51						+6·21	+6·22
4 3						2 52 46·4	— 8 13·90	13 22 39·0	16 52·19		
				+6·51						+6·90	+6·80
6 0	11 16 13·5	23 59 29·2	— 8 1·70								
				+6·93						+6·90	+7·00
8 3						0 54 42·8	— 7 47·48	11 42 22·0	16 51·52		
				+6·93						+6·74	+6·86
10 1	12 39 1·5	1 5 55·6	— 7 33·53								
				+6·80						+6·74	+6·62
12 4						3 39 13·6	— 7 19·20	14 42 58·0	16 52·05		
				+6·80							+6·98
14 0	11 4 54·0	23 15 56·4	— 7 6·90								

Concluded Longitude of Valentia from Kingstown = 16m 51s·76 West.

CHRONOMETER I.

Aug. 5 4	13 10 17·5	4 13 36·8	—22 55·74								
				+1·74							
7 4						4 30 24·0	—22 52·21	(Chron. 2306.) 12 55 28·5	16 51·85		+1·91
				+1·74						+1·62	+1·57
9 0	9 38 42·0	0 26 46·8	—22 49·06								
				+1·84				(Chron. 2306.)		+1·62	+1·67
11 3						2 24 44·0	—22 45·20	11 5 11·5	16 52·52		
				+1·84						+1·84	+2·01
13 0	9 59 13·5	0 31 24·8	—22 41·67					(TransitClock)			
				+1·47						+1·84	+1·67
15 2						0 42 20·0	—22 38·69	9 38 15·0	16 51·84		
				+1·47						+1·38	+1·27
17 1	10 58 32·0	1 14 45·6	—22 35·75								
				+1·57						+1·38	+1·49
19 3						2 46 15·2	—22 32·48	11 58 14·0	16 52·41		
				+1·57						+1·54	+1·65
21 1	11 53 37·0	1 53 55·6	—22 29·41								
				+1·40						+1·54	+1·43
23 2						1 25 45·6	—22 26·61	10 53 15·0	16 52·20		
				+1·40						+1·37	+1·37
25 2	12 59 14·0	2 43 35·6	—22 23·74								
				+1·42						+1·37	+1·37
27 3						2 57 50·0	—22 20·86	12 42 18·0	16 52·37		
				+1·42						+1·40	+1·47
29 0	10 54 52·0	0 23 47·2	—22 18·18								
				+1·49						+1·40	+1·33
31 3						2 40 20·0	—22 15·04	12 40 29·0	16 52·60		
				+1·49						+1·71	+1·65
Sep. 2 0	10 12 33·0	23 25 49·6	—22 12·26								
				+1·70						+1·71	+1·77
4 3						3 12 9·2	—22 8·57	13 28 8·0	16 52·21		
				+1·70						+1·60	+1·63
6 0	11 18 6·5	0 15 25·6	—22 5·39								
				+1·53						+1·60	+1·57
8 3						1 10 44·0	—22 2·25	11 44 8·0	16 52·25		
				+1·53						+1·46	+1·49
10 1	12 40 10·0	1 21 29·6	—21 59·21								
				+1·23						+1·46	+1·43
12 4						3 57 45·2	—21 56·60	14 46 53·0	16 51·89		
				+1·23							+1·03
14 0	11 7 8·5	23 32 58·0	—21 54·37								

Concluded Longitude of Valentia from Kingstown = 16m 52s·26 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer J.

Approximate Solar Time, 1844.	Comparisons at Kingstown: Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Valentia: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 11 37·5	4 14 49·6	−22 48·76							
				+3·63			(Chron. 2306.)			+3·76
7 4				+3·63	4 32 6·8	−22 41·38	12 57 22·5	16 51·79	+3·20	+3·50
9 0	9 39 56·5	0 27 46·8	−22 34·76	+3·09			(Chron. 2306.)		+3·20	+2·90
11 3				+3·09	2 57 20·0	−22 28·20	11 38 10·0	16 52·40	+3·17	+3·28
13 0	10 1 38·0	0 33 29·6	−22 22·36	+2·98			(Transit Clock)		+3·17	+3·06
15 2				+2·98	0 43 30·4	−22 16·31	9 39 48·0	16 51·88	+3·15	+2·90
17 1	11 0 16·5	1 16 4·4	−22 10·33	+3·40					+3·15	+3·40
19 3				+3·40	2 49 46·0	−22 3·26	12 2 15·0	16 52·08	+3·33	+3·40
21 1	11 54 50·0	1 54 35·6	−21 56·61	+3·23					+3·33	+3·26
23 2				+3·23	1 34 50·4	−21 50·12	11 2 58·0	16 52·08	+3·24	+3·20
25 2	13 2 46·0	2 46 26·8	−21 43·51	+3·10					+3·24	+3·28
27 3				+3·10	3 0 45·2	−21 37·23	12 45 58·0	16 51·79	+2·79	+2·92
29 0	10 57 18·0	0 25 26·0	−21 31·38	+2·75					+2·79	+2·66
31 3				+2·75	2 40 50·0	−21 25·58	12 41 49·0	16 52·28	+3·01	+2·84
Sep. 2 0	10 14 23·5	23 26 48·0	−21 20·47	+3·27					+3·01	+3·18
4 3				+3·27	3 16 56·0	−21 13·33	13 33 51·0	16 52·45	+3·25	+3·36
6 0	11 20 41·5	0 17 2·0	−21 7·22	+3·30					+3·25	+3·14
8 3				+3·30	1 13 22·0	−21 0·44	11 47 48·0	16 52·64	+3·43	+3·46
10 1	12 43 31·5	1 23 45·2	−20 53·86	+3·06					+3·43	+3·40
12 4				+3·06	3 59 33·2	−20 47·39	14 49 51·0	16 51·57		+2·72
14 0	11 8 48·5	23 33 25·2	−20 41·85							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·14 West.

Chronometer K.

Aug. 5 4	13 12 46·5	4 18 41·6	−25 31·95							
				+2·21			(Chron. 2306.)			+2·57
7 4				+2·21	4 37 10·8	−25 27·47	12 59 41·5	16 51·07	+2·41	+1·85
9 0	9 41 45·5	0 32 24·2	−25 23·46	+3·30			(Chron. 2306.)		+2·41	+2·97
11 3				+3·30	3 9 8·03	−25 16·44	11 47 11·0	16 52·63	+3·82	+3·63
13 0	10 3 58·5	0 38 37·6	−25 10·24	+3·95			(Transit Clock)		+3·82	+4·01
15 2				+3·95	0 53 31·2	−25 2·22	9 47 4·0	16 51·95	+3·87	+3·89
17 1	11 2 4·0	1 20 35·6	−24 54·32	+3·73					+3·87	+3·85
19 3				+3·73	2 56 26·4	−24 46·53	12 6 13·0	16 51·84	+3·42	+3·61
21 1	11 56 42·0	1 59 10·0	−24 39·31	+3·35					+3·42	+3·23
23 2				+3·35	1 45 20·8	−24 32·57	11 10 47·0	16 52·29	+2·94	+3·47
25 2	13 5 27·0	2 51 49·6	−24 25·74	+2·65					+2·94	+2·41

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER K.—*concluded.*

Comparisons at Kingstown.				Comparisons at Valentia.				
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3					3 7 50·4	−24 20·36	12 50 20·0	16 52·57		
				+2·65					+2·78	+2·89
29 0	10 59 11·5	0 30 3·2	−24 15·39							
				+2·22					+2·78	+2·67
31 3					2 49 44·0	−24 10·71	12 48 0·0	16 51·15		
Sep.				+2·22					+1·71	+1·77
2 0	10 16 28·5	23 31 38·8	−24 6·61							
				+1·87					+1·71	+1·65
4 3					3 22 40·0	−24 2·54	13 36 46·0	16 52·46		
				+1·87					+2·13	+2·09
6 0	11 22 46·0	0 21 58·0	−23 59·06							
				+2·36					+2·13	+2·17
8 3					1 25 56·0	−23 54·20	11 57 30·0	16 52·47		
				+2·36					+2·72	+2·55
10 1	12 45 2·5	1 28 11·6	−23 49·51							
				+2·92					+2·72	+2·89
12 4					4 5 55·2	−23 43·31	14 53 17·0	16 52·20		
				+2·92						+2·95
14 0	11 10 2·5	23 37 35·2	−23 38·03							

Concluded Longitude of Valentia from Kingstown = 16m 52s·03 West.

CHRONOMETER K*.

Aug.										
5. 4	13 14 24·0	4 16 41·8	−21 54·91							
				+7·50			(Chron. 2306.)			+7·74
7 4					4 34 49·0	−21 39·68	13 1 7·0	16 51·79		
				+7·50					+6·60	+7·26
9 0	9 43 32·0	0 30 13·0	−21 26·05				(Chron. 2306.)			
				+5·49					+6·60	+5·94
11 3					3 19 14·97	−21 14·33	12 1 24·0	16 51·09		
				+5·49					+5·40	+5·04
13 0	10 5 13·5	0 35 46·2	−21 4·04				(TransitClock)			
				+5·26					+5·40	+5·76
15 2					1 11 56·63	−20 53·28	10 9 43·0	16 50·99		
				+5·26					+4·72	+4·76
17 1	11 5 1·0	1 19 20·6	−20 42·79							
				+4·50					+4·72	+4·68
19 3					2 57 20·2	−20 33·39	12 11 21·0	16 51·61		
				+4·50					+4·06	+4·32
21 1	12 0 33·5	1 58 46·2	−20 24·65							
				+3·95					+4·06	+3·80
23 2					1 46 37·0	−20 16·75	11 16 20·0	16 52·20		
				+3·95					+3·83	+4·10
25 2	13 8 17·5	2 50 22·6	−20 8·73							
				+3·99					+3·83	+3·56
27 3					3 8 39·0	−20 0·62	12 55 29·0	16 52·76		
				+3·99					+4·40	+4·42
29 0	11 1 15·5	0 27 44·6	−19 53·12							
				+3·87					+4·40	+4·38
31 3					3 39 11·0	−19 44·90	13 42 2·0	16 50·74		
Sep.				+3·87					+3·57	+3·36
2 0	10 19 1·5	23 29 42·6	−19 37·82							
				+4·03					+3·57	+3·78
4 3					3 23 0·6	−19 29·03	13 41 41·0	16 52·37		
				+4·03					+3·80	+4·28
6 0	11 23 53·5	0 18 27·8	−19 21·54							
				+3·13					+3·80	+3·32
8 3					1 26 29·0	−19 15·04	12 2 44·0	16 51·48		
				+3·13					+2·90	+2·94
10 1	12 46 54·5	1 25 22·6	−19 8·81							
				+2·90					+2·90	+2·86
12 4					4 7 52·2	−19 2·66	14 59 56·0	16 51·94		
				+2·90						+2·94
14 0	11 11 58·0	23 34 49·8	−18 57·45							

Concluded Longitude of Valentia from Kingstown = 16m 51s·94 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer M.

Comparisons at Kingstown.						Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.		Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s		h m s	m s	h m s	m s	s	s
5 4	13 15 41·0	4 20 11·2	−24 7·51					(Chron. 2306.)			−0·31
7 4				−0·06		4 39 24·0	−24 7·64	13 3 14·0	16 52·18		
9 0	9 45 24·0	0 34 46·4	−24 7·75	−0·06						+0·01	+0·19
11 3				+0·32		3 30 50·0	−24 7·07	(Chron. 2306.) 12 10 6·0	16 52·71	+0·01	−0·17
13 0	10 7 16·0	0 40 50·8	−24 6·48	+0·32						+0·71	+0·81
15 2				+0·63		1 26 1·6	−24 5·19	(Transit Clock) 10 20 37·0	16 51·80	+0·71	+0·61
17 1	11 6 29·5	1 24 10·0	−24 3·94	+0·63						+0·76	+0·65
19 3				+0·69		3 6 1·22	−24 2·50	12 16 34·0	16 51·38	+0·76	+0·87
21 1	12 1 55·0	2 3 44·0	−24 1·17	+0·69						+0·54	+0·51
23 2				+0·73		1 55 6·0	−23 59·71	11 21 7·0	16 52·03	+0·54	+0·57
25 2	13 10 10·5	2 56 4·8	−23 58·23	+0·73						+0·29	+0·89
27 3				−0·26		3 13 50·0	−23 58·76	12 56 43·0	16 51·82	+0·29	−0·31
29 0	11 3 17·5	0 33 52·4	−23 59·25	−0·26						−0·05	−0·21
31 3				+0·02		3 44 14·0	−23 59·22	13 42 50·0	16 51·56	−0·05	+0·11
Sep. 2 0	10 20 37·0	23 35 39·2	−23 59·19	+0·02						+0·21	−0·07
4 3				+0·47		3 28 22·0	−23 58·16	13 42 34·0	16 51·79	+0·21	+0·49
6 0	11 26 30·0	0 25 39·6	−23 57·28	+0·47						+0·65	+0·45
8 3				+0·35		1 47 45·2	−23 56·55	12 19 22·0	16 50·85	+0·65	+0·85
10 1	12 50 7·0	1 33 21·6	−23 55·85	+0·35						+0·15	−0·15
12 4				+0·54		4 21 16·0	−23 54·71	15 8 29·0	16 52·08	+0·15	+0·45
14 0	11 14 58·0	23 42 45·6	−23 53·74	+0·54							+0·63

Concluded Longitude of Valentia from Kingstown = 16m 51s·77 West.

Chronometer N.

Aug. 5 4	13 16 57·5	4 20 42·4	−23 22·43								
7 4				+1·66		4 41 26·4	−23 19·05	(Chron. 2306.) 13 6 5·5	16 52·13		+1·47
9 0	9 47 6·0	0 35 36·4	−23 16·03	+1·66						+1·72	+1·85
11 3				+1·76		3 33 59·98	−23 12·26	(Chron. 2306.) 12 14 12·0	16 52·15	+1·72	+1·59
13 0	10 9 1·0	0 41 38·0	−23 8·97	+1·76						+1·95	+1·93
15 2				+2·02		1 33 40·0	−23 4·84	(Transit Clock) 10 29 17·0	16 51·98	+1·95	+1·97
17 1	11 8 22·5	1 24 59·6	−23 0·84	+2·02						+2·38	+2·07
19 3				+2·28		3 7 50·0	−22 56·09	12 19 30·0	16 51·04	+2·38	+2·69
21 1	12 4 59·0	2 5 38·0	−22 51·66	+2·28						+1·70	+1·87
23 2				+2·03		2 4 20·0	−22 47·56	11 31 34·0	16 52·88	+1·70	+1·53
25 2	13 11 58·0	2 56 37·2	−22 43·42	+2·03						+2·50	+2·53
				+2·68						+2·50	+2·47

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER N.—*concluded.*

Approximate Solar Time, 1844.	Comparisons at Kingstown: Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Valentia: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3				+2·68	3 15 45·2	−22 37·95	12 59 59·0	16 52·35		
29 0	11 5 29·0	0 34 37·2	−22 32·91	+2·13					+2·80	+2·89
31 3				+2·13	3 44 34·0	−22 28·33	13 44 42·0	16 50·75	+2·80	+2·71
Sep. 2 0	10 23 33·0	23 37 0·0	−22 24·46	+2·06					+1·79	+1·55
4 3				+2·06	3 32 52·0	−22 19·98	13 48. 43·0	16 51·96	+1·79	+2·03
6 0	11 28 15·0	0 25 43·2	−22 16·16	+2·17					+1·97	+2·09
8 3				+2·17	1 49 32·4	−22 11·65	12 22 58·0	16 52·55	+1·97	+1·85
10 1	12 51 26·5	1 32 52·4	−22 7·36	+2·95					+2·78	+2·49
12 4				+2·95	4 27 51·6	−22 1·08	15 17. 0·0	16 51·70	+2·78	+3·07
14 0	11 17 5·5	23 42 54·8	−21 55·79							+2·83

Concluded Longitude of Valentia from Kingstown = 16m 51s·89 West.

CHRONOMETER O.

Aug. 5 4	13 18 15·5	4 9 38·8	−11 1·03							
7 4				+2·75	4 29 48·8	−10 55·44	(Chron. 2306.) 13 6 52·5	16 51·27		+3·00
9 0	9 49 28·0	0 25 32·4	−10 50·42	+2·75					+2·77	+2·50
11 3				+3·26	3 29 36·0	−10 43·46	(Chron. 2306.) 12 22 18·0	16 52·29	+2·77	+3·04
13 0	10 10 44·5	0 30 49·6	−10 37·35	+3·26					+3·22	+3·48
15 2				+2·75	1 23 10·0	−10 31·69	(TransitClock) 10 31 21·0	16 51·46	+3·22	+2·96
17 1	11 10 45·5	1 14 47·6	−10 26·23	+2·75					+2·80	+2·54
19 3				+3·06	2 57 47·2	−10 19·84	12 22 3·0	16 51·90	+2·80	+3·06
21 1	12 6 19·0	1 54 20·0	−10 13·88	+3·06					+3·32	+3·06
23 2				+3·59	1 55 11·6	−10 6·67	11 35 8·0	16 51·93	+3·32	+3·58
25 2	13 14 16·0	2 46 10·8	− 9 59·40	+3·59					+3·32	+3·60
27 3				+3·27	3 9 14·0	− 9 52·78	13 6 14·0	16 52·34	+3·32	+3·04
29 0	11 7 24·0	0 23 45·6	− 9 46·62	+3·27					+3·22	+3·50
31 3				+2·99	3 32 43·96	− 9 40·22	13 45 39·0	16 51·98	+3·22	+2·94
Sep. 2 0	10 25 21·0	23 25 58·0	− 9 34·76	+2·99					+3·03	+3·04
4 3				+2·94	3 24 26·4	− 9 28·36	13 53 10·0	16 51·70	+3·03	+3·02
6 0	11 30 53·5	0 15 28·0	− 9 22·89	+2·94					+3·04	+2·86
8 3				+3·28	1 42 0·4	− 9 16·09	12 28 18·0	16 51·98	+3·04	+3·22
10 1	12 53 21·0	1 21 48·8	− 9 9·57	+3·28					+2·96	+3·34
12 4				+2·22	4 18 15·2	− 9 4·86	15 20 21·0	16 51·06	+2·96	+2·58
14 0	11 18 21·0	23 31 15·2	− 9 0·89	+2·22						+1·86

Concluded Longitude of Valentia from Kingstown = 16m 51s·85 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer P.

Approximate Solar Time, 1844.	Comparisons at Kingstown: Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Valentia: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 20 14·5	4 34 35·2	−33 58·76	−6·10			(Chron. 2306.)			−5·88
7 4				−6·10	4 56 35·6	−34 11·24	13 10 24·5	16 50·84	−6·01	−6·32
9 0	9 54 22·5	0 53 58·0	−34 22·33	−5·76			(Chron. 2306.)		−6·01	−5·70
11 3				−5·76	4 10 16·02	−34 34·82	12 39 10·5	16 51·17	−5·85	−5·82
13 0	10 13 52·5	0 58 5·2	−34 45·47	−5·60			(Transit Clock)		−5·85	−5·88
15 2				−5·60	1 51 24·08	−34 57·07	10 35 10·0	16 51·78	−5·15	−5·32
17 1	11 14 27·0	1 43 10·4	−35 8·14	−5·01					−5·15	−4·98
19 3				−5·01	3 26 59·6	−35 18·67	12 26 18·0	16 51·16	−4·92	−5·04
21 1	12 10 28·0	2 23 42·8	−35 28·36	−5·08					−4·92	−4·80
23 2				−5·08	2 27 39·18	−35 38·64	11 42 6·0	16 50·68	−5·45	−5·36
25 2	13 21 26·5	3 19 9·6	−35 48·87	−5·49					−5·45	−5·54
27 3				−5·49	3 42 45·18	−36 0·09	13 13 40·0	16 51·42	−5·60	−5·44
29 0	11 11 12·5	0 53 57·2	−36 10·34	−5·40					−5·60	−5·76
31 3				−5·40	4 10 40·0	−36 22·04	13 56 55·0	16 52·04	−5·24	−5·04
Sep. 2 0	10 27 27·5	23 55 1·2	−36 31·81	−5·35					−5·24	−5·44
4 3				−5·35	3 58 49·2	−36 43·61	14 0 19·0	16 51·41	−5·18	−5·26
6 0	11 35 12·0	0 47 16·4	−36 53·50	−5·23					−5·18	−5·10
8 3				−5·23	2 20 30·0	−37 4·42	12 39 2·0	16 50·99	−5·32	−5·36
10 1	12 58 21·5	1 54 53·6	−37 14·68	−5·12					−5·32	−5·28
12 4				−5·12	5 0 29·2	−37 25·71	15 34 16·0	16 51·47		−4·96
14 0	11 23 42·0	0 5 9·2	−37 34·76							

Concluded Longitude of Valentia from Kingstown = 16m 51s·27 West.

Chronometer Q.

Aug.										
5 4	13 21 26·5	4 23 52·0	−22 3·76	−1·15			(Chron. 2306.)			−0·42
7 4				−1·15	4 46 10·8	−22 6·11	13 12 5·5	16 50·43	−1·37	−1·88
9 0	9 56 43·0	0 44 4·0	−22 8·21	−0·01			(Chron. 2306.)		−1·37	−0·86
11 3				−0·01	4 2 2·8	−22 8·23	12 43 22·0	16 53·73	+1·34	+0·84
13 0	10 16 12·5	0 47 47·6	−22 8·24	+1·82			(Transit Clock)		+1·34	+1·84
15 2				+1·82	1 43 15·18	−22 4·50	10 39 54·0	16 52·23	+0·98	+1·80
17 1	11 16 45·0	1 32 20·8	−22 0·92	−0·16					+0·98	+0·16
19 3				−0·16	3 23 4·0	−22 1·25	12 35 41·0	16 51·50	−0·63	−0·48
21 1	12 13 28·5	2 13 16·0	−22 1·56	−0·38					−0·63	−0·78
23 2				−0·38	2 23 31·6	−22 2·33	11 51 34·0	16 52·94	+0·07	+0·02
25 2	13 23 29·0	3 7 26·0	−22 3·10	+0·48					+0·07	+0·12

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER Q.—*concluded.*

Comparisons at Kingstown.						Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.		Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s		h m s	m s	h m s	m s	s	s
27 3					+0·48	3 31 33·2	−22 2·13	13 16 25·0	16 52·85		
29 0	11 13 1·5	0 41 36·8	−22 1·24		+1·63					+0·83	+0·84
31 3					+1·63	3 59 42·0	−21 57·75	14 0 20·0	16 53·88	+0·83	+0·82
Sep. 2 0	10 29 12·0	23 42 8·4	−21 54·80		+1·51					+2·17	+2·44
4 3					+1·51	3 48 30·4	−21 51·51	14 4 53·0	16 51·45	+2·17	+1·90
6 0	11 36 33·0	0 33 32·4	−21 48·71		+0·92					+1·58	+1·12
8 3					+0·92	2 13 28·0	−21 46·80	12 47 20·0	16 49·96	+1·58	+2·04
10 1	13 1 28·5	1 42 30·4	−21 44·99		+0·19					−0·23	−0·20
12 4					+0·19	4 50 34·8	−21 44·57	15 40 2·0	16 53·15	−0·23	−0·26
14 0	11 25 56·5	23 51 32·8	−21 44·23								+0·64

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·15 West.

CHRONOMETER R.

Aug. 5 4	13 22 41·5	4 31 11·6	−28 8·56		+3·24						
7 4					+3·24	4 53 47·6	−28 1·96	(Chron. 2306.) 13 13 44·0	16 53·17		+2·71
9 0	9 58 27·0	0 51 35·6	−27 56·10		+4·37					+3·65	+3·77
11 3					+4·37	4 13 8·0	−27 46·62	(Chron. 2306.) 12 48 49·5	16 53·94	+3·65	+3·53
13 0	10 18 2·5	0 55 7·6	−27 38·54		+5·24					+5·15	+5·21
15 2					+5·24	2 7 48·8	−27 27·66	(TransitClock) 10 59 7·0	16 52·82	+5·15	+5·09
17 1	11 18 58·5	1 39 50·4	−27 17·38		+5·65					+5·65	+5·39
19 3					+5·65	3 34 55·6	−27 5·48	12 42 29·0	16 51·99	+5·65	+5·91
21 1	12 15 59·5	2 20 39·6	−26 54·56		+5·66					+5·45	+5·39
23 2					+5·66	2 34 13·2	−26 43·08	11 57 36·0	16 52·76	+5·45	+5·51
25 2	13 27 7·0	3 15 32·0	−26 31·70		+5·80					+5·75	+5·81
27 3					+5·80	3 39 15·2	−26 19·84	13 19 50·0	16 52·68	+5·75	+5·69
29 0	11 15 16·5	0 47 59·2	−26 9·01		+6·20					+6·10	+5·91
31 3					+6·20	4 5 40·0	−25 55·61	14 2 22·0	16 52·35	+6·10	+6·29
Sep. 2 0	10 31 11·5	23 47 57·2	−25 44·42		+6·50					+6·38	+6·11
4 3					+6·50	3 57 1·2	−25 30·15	14 9 45·0	16 52·39	+6·38	+6·65
6 0	11 39 8·0	0 39 36·4	−25 18·13		+6·46					+6·75	+6·35
8 3					+6·46	2 23 32·0	−25 4·59	12 54 6·0	16 51·27	+6·75	+7·15
10 1	13 3 17·5	1 47 26·0	−24 51·89		+5·63					+5·62	+5·77
12 4					+5·63	5 4 30·0	−24 39·73	15 51 4·0	16 52·99	+5·62	+5·47
14 0	11 27 48·5	23 56 10·0	−24 29·74								+5·79

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·41 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer S.

Comparisons at Kingstown.					Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 24 5·5	4 22 52·8	−18 25·99				(Chron. 2306.)			
				+7·25	4 45 40·8	−18 11·24	13 15 27·0	16 54·37		+6·65
7 4				+7·25					+7·67	+7·85
9 0	10 3 19·5	0 46 29·2	−17 57·99				(Chron. 2306.)		+7·67	+7·49
				+8·08	4 9 53·96	−17 40·59	12 55 42·0	16 54·54		
11 3				+8·08					+8·10	+8·67
13 0	10 19 18·0	0 46 10·0	−17 25·65				(TransitClock)		+8·10	+7·53
				+8·00	2 5 1·58	−17 9·11	11 6 38·0	16 54·35		
15 2				+8·00					+8·10	+8·47
17 1	11 21 28·5	1 31 56·0	−16 53·40						+8·10	+7·73
				+6·20	3 43 28·4	−16 40·34	13 1 32·0	16 50·03		
19 3				+6·20					+5·93	+4·67
21 1	12 18 26·5	2 12 40·0	−16 28·36						+5·93	+7·19
					2 30 27·2	−16 15·79	12 4 20·0	16 51·16		
23 2										
25 2	13 28 42·5	3 6 13·6	−15 38·06							
				+5·94	3 30 28·0	−15 26·03	13 21 56·0	16 53·65		+5·70
27 3				+5·94					+6·10	+6·18
29 0	11 17 41·0	0 39 29·2	−15 14·90						+6·10	+6·02
				+5·30	3 56 4·0	−15 3·50	14 3 39·0	16 51·67		
31 3				+5·30					+4·72	+4·58
Sep.										
2 0	10 33 52·5	23 39 47·2	−14 53·86						+4·72	+4·86
				+5·94	3 52 16·0	−14 40·85	14 15 47·0	16 55·50		
4 3				+5·94					+6·27	+7·02
6 0	11 40 55·0	0 30 34·8	−14 29·82						+6·27	+5·52
				+5·07	2 16 33·2	−14 19·22	12 57 52·0	16 52·44		
8 3				+5·07					+5·44	+4·62
10 1	13 5 12·5	1 38 38·0	−14 9·20						+5·44	+6·26
				+6·20	4 54 34·4	−13 55·90	15 51 52·0	16 53·35		
12 4				+6·20						+6·14
14 0	11 29 40·5	23 47 16·8	−13 44·84							

Concluded Longitude of Valentia from Kingstown = $16^m\ 53^s{\cdot}24$ West.

Chronometer T.

Aug.										
5 4	13 25 44·5	4 29 32·8	−23 27·26							
				−2·20	4 54 24·8	−23 31·72	(Chron. 2306.) 13 18 54·0	16 51·44		−1·86
7 4				−2·20					−2·57	−2·54
9 0	10 5 14·5	0 54 1·6	−23 35·71				(Chron. 2306.)		−2·57	−2·60
				−2·58	4 20 30·0	−23 41·30	13 0 20·5	16 52·10		
11 3				−2·58					−2·70	−2·56
13 0	10 21 11·5	0 54 23·6	−23 46·06				(TransitClock)		−2·70	−2·84
				−2·91	2 18 30·0	−23 52·09	11 13 27·0	16 51·90		
15 2				−2·91					−2·92	−2·98
17 1	11 22 37·5	1 40 9·2	−23 57·78						−2·92	−2·86
				−3·24	4 26 23·2	−24 4·70	13 37 7·0	16 51·24		
19 3				−3·24					−3·94	−3·62
21 1	12 20 7·5	2 22 3·2	−24 10·84						−3·94	−4·26
				−4·13	2 41 27·2	−24 19·22	12 7 16·0	16 52·19		
23 2				−4·13					−4·25	−4·00
25 2	13 30 55·0	3 17 15·2	−24 27·51							
				−4·84					−4·25	−4·50

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER T.—*concluded.*

Comparisons at Kingstown.				Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3					3 42 58·4	−24 37·35	13 25 18·0	16 51·27		
				−4·84					−4·77	−5·18
29 0	11 18 48·5	0 50 8·0	−24 46·38							
				−4·46					−4·77	−4·36
31 3					4 10 8·0	−24 56·01	14 7 51·0	16 51·83		
				−4·46					−4·98	−4·56
Sep. 2 0	10 39 30·0	23 55 34·0	−25 4·08							
				−5·38					−4·98	−5·40
4 3					4. 5 36·0	−25 15·88	14 18 36·0	16 51·91		
				−5·38					−5·47	−5·36
6 0	11 43 21·0	0 43 56·4	−25 25·82							
				−5·95					−5·47	−5·58
8 3					2 33 16·0	−25 38·32	13 3 18·0	16 51·03		
				−5·95					−6·52	−6·32
10 1	13 7 34·5	1 52 40·4	−25 49·99							
				−6·32					−6·52	−6·72
12 4					5 12 2·42	−26 3·65	15 57 14·0	16 52·49		
				−6·32						−5·92
14 0	11 31 44·0	0 1 50·0	−26 14·87							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 51ˢ·96 West.

CHRONOMETER U.

Aug. 5 4	13 26 53·5	4 26 57·2	−19 42·86							
				+4·23			(Chron. 2306.)			+4·05
7 4					4 51 13·6	−19 34·25	13 19 40·0	16 51·83		
				+4·23					+4·45	+4·41
9 0	10 7 8·0	0 51 45·6	−19 26·52				(Chron. 2306.)			
				+4·53	4 25 10·0	−19 16·73	13 9 27·0	16 51·65	+4·45	+4·49
11 3										
				+4·53					+4·70	+4·57
13 0	10 23 42·0	0 52 16·0	−19 8·37				(Transit Clock)			
				+4·48					+4·70	+4·83
15 2					2 20 4·0	−18 59·02	11 19 56·0	16 51·00		
				+4·48					+4·52	+4·13
17 1	11 24 22·5	1 36 46·4	−18 50·26							
				+4·70					+4·52	+4·91
19 3					4 24 31·22	−18 40·26	13 40 40·0	16 51·28		
				+4·70					+4·35	+4·49
21 1	12 21 20·0	2 17 36·0	−18 31·34							
				+4·72					+4·35	+4·21
23 2					2 40 30·4	−18 21·74	12 12 17·0	16 52·70		
				+4·72					+4·84	+5·23
25 2	13 33 25·5	3 13 30·0	−18 12·23							
				+4·70					+4·84	+4·45
27 3					3 43 58·4	−18 2·65	13 32 53·0	16 52·20		
				+4·70					+4·92	+4·95
29 0	11 20 36·5	0 45 3·2	−17 53·87							
				+4·48					+4·92	+4·89
31 3					4 4 32·0	−17 44·23	14 9 28·0	16 50·88		
				+4·48					+4·13	+4·07
Sep. 2 0	10 40 51·0	23 49 26·8	−17 36·10							
				+4·50					+4·13	+4·19
4 3					4 0 34·4	−17 26·28	14 21 24·0	16 52·37		
				+4·50					+4·97	+4·81
6 0	11 44 37·5	0 37 4·8	−17 17·93							
				+4·88					+4·97	+5·13
8 3					2 29 20·0	−17 7·73	13 7 53·0	16 51·36		
				+4·88					+4·52	+4·63
10 1	13 9 45·5	1 45 59·2	−16 58·15							
				+4·38					+4·52	+4·41
12 4					5 7 34·0	−16 48·74	16 2 2·0	16 51·75		
				+4·38						+4·35
14 0	11 34 40·0	23 55 11·6	−16 40·95							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 51ˢ·69 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer W.

Comparisons at Kingstown.					Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 28 16·0	4 44 2·2	−35 25·57							
				−7·73			(Chron. 2306.)			−7·82
7 4					5 8 58·6	−35 41·35	13 21 18·0	16 52·00		
				−7·73					−7·90	−7·64
9 0	10 9 29·0	1 10 35·0	−35 55·30				(Chron. 2306.)			
				−8·03	4 44 59·0	−36 12·80	13 12 20·0	16 52·07	−7·90	−8·16
11 3										
				−8·03					−7·75	−7·90
13 0	10 26 46·0	1 12 38·6	−36 27·48				(TransitClock)			
				−7·76	2 42 23·4	−36 43·74	11 24 31·0	16 51·43	−7·75	−7·60
15 2										
				−7·76					−7·58	−7·92
17 1	11 26 30·5	1 57 2·6	−36 58·82							
				−7·42					−7·58	−7·24
19 3					4 46 58·2	−37 14·70	13 44 33·0	16 51·45		
				−7·42					−7·58	−7·60
21 1	12 23 9·5	2 38 22·6	−37 28·72							
				−7·49					−7·58	−7·56
23 2					3 4 57·0	−37 44·01	12 17 23·0	16 51·86		
				−7·49					−7·28	−7·42
25 2	13 35 18·5	3 35 9·4	−37 58·94							
				−7·10					−7·28	−7·14
27 3					4 9 43·0	−38 13·47	13 38 28·0	16 51·88		
				−7·10					−7·25	−7·06
29 0	11 23 0·0	1 7 59·0	−38 26·57							
				−7·52					−7·25	−7·44
31 3					4 26 36·2	−38 42·89	14 10 33·0	16 51·59		
				−7·52					−7·70	−7·60
Sep. 2 0	10 43 30·5	0 13 26·2	−38 56·44							
				−7·70					−7·70	−7·80
4 3					4 34 2·2	−39 13·44	14 33 7·0	16 51·91		
				−7·70					−7·50	−7·60
6 0	11 46 46·5	1 1 23·0	−39 27·48							
				−7·19					−7·50	−7·40
8 3					2 55 52·2	−39 42·65	13 11 50·0	16 52·29		
				−7·19					−7·17	−6·98
10 1	13 13 23·0	2 12 34·6	−39 56·64							
				−7·65					−7·17	−7·36
12 4					5 37 5·0	−40 13·24	16 8 10·0	16 51·25		
				−7·65						−7·94
14 0	11 36 24·0	0 20 41·0	−40 26·63							

Concluded Longitude of Valentia from Kingstown = 16m 51s·79 West.

Chronometer X.

Aug. 5 4	13 30 22·0	4 35 46·6	−25 4·32							
				−0·97			(Chron. 2306.)			−0·92
7 4					4 59 54·2	−25 6·31	13 22 49·0	16 51·88		
				−0·97					−1·06	−1·02
9 0	10 10 32·0	1 0 50·6	−25 8·07				(Chron. 2306.)			
				−1·13	4 39 3·19	−25 10·52	13 17 27·5	16 51·86	−1·06	−1·10
11 3										
				−1·13					−1·26	−1·16
13 0	10 28 42·0	1 3 19·4	−25 12·59				(TransitClock)			
				−1·34	2 40 21·0	−25 15·41	11 33 58·0	16 51·90	−1·26	−1·36
15 2										
				−1·34					−1·03	−1·32
17 1	11 29 29·0	1 48 19·8	−25 18·01							
				−0·92					−1·03	−0·74
19 3					4 38 23·0	−25 19·97	13 47 53·0	16 51·53		
				−0·92					−0·93	−1·10
21 1	12 26 39·5	2 29 45·0	−25 21·70							
				−0·65					−0·93	−0·76
23 2					2 54 13·0	−25 23·03	12 19 0·0	16 52·10		
				−0·65					−0·55	−0·54
25 2	13 37 9·0	3 24 25·0	−25 24·33							
				−0·60					−0·55	−0·56

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER X.—*concluded.*

Approximate Solar Time, 1844.	Comparisons at Kingstown: Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Valentia: Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3				−0·60	3 59 14·63	−25 25·56	13 40 48·0	16 51·80	−0·81	−0·64
29 0	11 24 51·0	0 56 49·8	−25 26·67	−1·34					−0·81	−0·98
31 3				−1·34	4 15 23·0	−25 29·55	14 12 34·0	16 51·07	−1·57	−1·70
Sep. 2 0	10 46 5·0	0 2 35·8	−25 31·96	−1·31					−1·57	−1·44
4 3				−1·31	4 23 54·2	−25 34·84	14 36 38·0	16 52·07	−1·25	−1·18
6 0	11 49 5·5	0 49 51·4	−25 37·26	−0·89					−1·25	−1·32
8 3				−0·89	2 50 46·6	−25 39·12	13 20 49·0	16 52·69	−0·72	−0·46
10 1	13 14 43·0	1 59 38·6	−25 40·85	−1·01					−0·72	−0·98
12 4				−1·01	5 24 23·0	−25 43·03	16 9 58·0	16 51·76		−1·04
14 0	11 38 4·5	0 7 39·4	−25 44·81							

Concluded Longitude of Valentia from Kingstown = 16m 51s·87 West.

CHRONOMETER Y.

Aug. 5 4	13 31 36·0	4 32 21·4	−20 25·32							
7 4				+2·72	4 57 28·2	−20 19·79	(Chron. 2306.) 13 25 10·5	16 51·28		+2·90
9 0	10 12 15·5	0 57 40·6	−20 14·86	+2·72					+2·79	+2·54
11 3				+3·43	4 40 9·77	−20 7·38	(Chron. 2306.) 13 23 37·5	16 52·59	+2·79	+3·04
13 0	10 31 42·0	1 1 7·4	−20 1·08	+3·43					+3·75	+3·82
15 2				+3·73	2 38 55·4	−19 53·33	(TransitClock) 11 37 55·0	16 52·02	+3·75	+3·68
17 1	11 32 21·0	1 45 39·4	−19 46·07	+3·73					+4·10	+3·78
19 3				+4·45	4 39 35·0	−19 36·59	13 54 49·0	16 52·03	+4·10	+4·42
21 1	12 27 21·5	2 24 33·4	−19 28·21	+4·45					+4·22	+4·48
23 2				+3·95	2 53 43·0	−19 20·18	12 24 34·0	16 51·86	+4·22	+3·96
25 2	13 39 37·5	3 20 41·0	−19 12·23	+3·95					+3·43	+3·94
27 3				+3·54	4 1 33·0	−19 4·96	13 49 27·0	16 53·19	+3·43	+2·92
29 0	11 26 13·5	0 51 43·8	−18 58·40	+3·54					+4·08	+4·16
31 3				+4·52	4 20 50·2	−18 48·64	14 24 42·0	16 53·15	+4·08	+4·00
Sep. 2 0	10 47 52·0	23 57 31·0	−18 40·45	+4·52					+4·86	+5·04
4 3				+4·68	4 20 41·0	−18 30·15	14 40 30·0	16 52·21	+4·86	+4·68
6 0	11 50 45·5	0 44 15·4	−18 21·54	+4·68					+5·24	+4·68
8 3				+5·58	2 47 7·0	−18 9·79	13 24 40·0	16 52·03	+5·24	+5·80
10 1	13 17 13·0	1 54 26·2	−17 58·86	+5·58					+5·66	+5·36
12 4				+5·13	5 26 18·2	−17 47·75	16 19 51·0	16 50·83	+5·66	+5·96
14 0	11 43 58·0	0 5 25·8	−17 38·66	+5·13						+4·30

Concluded Longitude of Valentia from Kingstown = 16m 52s·03 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer W.

Comparisons at Kingstown.					Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 28 16·0	4 44 2·2	−35 25·57	−7·73			(Chron. 2306.)			−7·82
7 4				−7·73	5 8 58·6	−35 41·35	13 21 18·0	16 52·00	−7·90	−7·64
9 0	10 9 29·0	1 10 35·0	−35 55·30	−8·03			(Chron. 2306.)		−7·90	−8·16
11 3				−8·03	4 44 59·0	−36 12·80	13 12 20·0	16 52·07	−7·75	−7·90
13 0	10 26 46·0	1 12 38·6	−36 27·48	−7·76			(TransitClock)		−7·75	−7·60
15 2				−7·76	2 42 23·4	−36 43·74	11 24 31·0	16 51·43	−7·58	−7·92
17 1	11 26 30·5	1 57 2·6	−36 58·82	−7·42					−7·58	−7·24
19 3				−7·42	4 46 58·2	−37 14·70	13 44 33·0	16 51·45	−7·58	−7·60
21 1	12 23 9·5	2 38 22·6	−37 28·72	−7·49					−7·58	−7·56
23 2				−7·49	3 4 57·0	−37 44·01	12 17 23·0	16 51·86	−7·28	−7·42
25 2	13 35 18·5	3 35 9·4	−37 58·94	−7·10					−7·28	−7·14
27 3				−7·10	4 9 43·0	−38 13·47	13 38 28·0	16 51·88	−7·25	−7·06
29 0	11 23 0·0	1 7 59·0	−38 26·57	−7·52					−7·25	−7·44
31 3				−7·52	4 26 36·2	−38 42·89	14 10 33·0	16 51·59	−7·70	−7·60
Sep. 2 0	10 43 30·5	0 13 26·2	−38 56·44	−7·70					−7·70	−7·80
4 3				−7·70	4 34 2·2	−39 13·44	14 33 7·0	16 51·91	−7·50	−7·60
6 0	11 46 46·5	1 1 23·0	−39 27·48	−7·19					−7·50	−7·40
8 3				−7·19	2 55 52·2	−39 42·65	13 11 50·0	16 52·29	−7·17	−6·98
10 1	13 13 23·0	2 12 34·6	−39 56·64	−7·65					−7·17	−7·36
12 4				−7·65	5 37 5·0	−40 13·24	16 8 10·0	16 51·25		−7·94
14 0	11 36 24·0	0 20 41·0	−40 26·63							

Concluded Longitude of Valentia from Kingstown = $16^m\ 51^s\cdot79$ West.

Chronometer X.

Aug. 5 4	13 30 22·0	4 35 46·6	−25 4·32	−0·97			(Chron. 2306.)			−0·92
7 4				−0·97	4 59 54·2	−25 6·31	13 22 49·0	16 51·88	−1·06	−1·02
9 0	10 10 32·0	1 0 50·6	−25 8·07	−1·13			(Chron. 2306.)		−1·06	−1·10
11 3				−1·13	4 39 3·19	−25 10·52	13 17 27·5	16 51·86	−1·26	−1·10
13 0	10 28 42·0	1 3 19·4	−25 12·59	−1·34			(TransitClock)		−1·26	−1·30
15 2				−1·34	2 40 21·0	−25 15·41	11 33 58·0	16 51·90	−1·03	−1·35
17 1	11 29 29·0	1 48 19·8	−25 18·01	−0·92					−1·03	−0·74
19 3				−0·92	4 38 23·0	−25 19·97	13 47 53·0	16 51·53	−0·93	−1·10
21 1	12 26 39·5	2 29 45·0	−25 21·70	−0·65					−0·93	−0·70
23 2				−0·65	2 54 13·0	−25 23·03	12 19 0·0	16 52·10	−0·55	−0·54
25 2	13 37 9·0	3 24 25·0	−25 24·33	−0·60					−0·55	−0·50

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER X.—*concluded.*

Approximate Solar Time, 1844.	Comparisons at Kingstown. Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Comparisons at Valentia. Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3					3 59 14·63	−25 25·56	13 40 48·0	16 51·80		
				−0·60					−0·81	−0·64
29 0	11 24 51·0	0 56 49·8	−25 26·67							
				−1·34					−0·81	−0·98
31 3					4 15 23·0	−25 29·55	14 12 34·0	16 51·07		
Sep.				−1·34					−1·57	−1·70
2 0	10 46 5·0	0 2 35·8	−25 31·96							
				−1·31					−1·57	−1·44
4 3					4 23 54·2	−25 34·84	14 36 38·0	16 52·07		
				−1·31					−1·25	−1·18
6 0	11 49 5·5	0 49 51·4	−25 37·26							
				−0·89					−1·25	−1·32
8 3					2 50 46·6	−25 39·12	13 20 49·0	16 52·69		
				−0·89					−0·72	−0·46
10 1	13 14 43·0	1 59 38·6	−25 40·85							
				−1·01					−0·72	−0·98
12 4					5 24 23·0	−25 43·03	16 9 58·0	16 51·76		
				−1·01						−1·04
14 0	11 38 4·5	0 7 39·4	−25 44·81							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 51ˢ·87 West.

CHRONOMETER Y.

Aug.										
5 4	13 31 36·0	4 32 21·4	−20 25·32							
				+2·72			(Chron. 2306.)			+2·90
7 4					4 57 28·2	−20 19·79	13 25 10·5	16 51·28		
				+2·72					+2·79	+2·54
9 0	10 12 15·5	0 57 40·6	−20 14·86							
				+3·43			(Chron. 2306.)		+2·79	+3·04
11 3					4 40 9·77	−20 7·38	13 23 37·5	16 52·59		
				+3·43					+3·75	+3·82
13 0	10 31 42·0	1 1 7·4	−20 1·08				(TransitClock)			
				+3·73					+3·75	+3·68
15 2					2 38 55·4	−19 53·33	11 37 55·0	16 52·02		
				+3·73					+4·10	+3·78
17 1	11 32 21·0	1 45 39·4	−19 46·07							
				+4·45					+4·10	+4·42
19 3					4 39 35·0	−19 36·59	13 54 49·0	16 52·03		
				+4·45					+4·22	+4·48
21 1	12 27 21·5	2 24 33·4	−19 28·21							
				+3·95					+4·22	+3·96
23 2					2 53 43·0	−19 20·18	12 24 34·0	16 51·86		
				+3·95					+3·43	+3·94
25 2	13 39 37·5	3 20 41·0	−19 12·23							
				+3·54					+3·43	+2·92
27 3					4 1 33·0	−19 4·96	13 49 27·0	16 53·19		
				+3·54					+4·08	+4·16
29 0	11 26 13·5	0 51 43·8	−18 58·40							
				+4·52					+4·08	+4·00
31 3					4 20 50·2	−18 48·64	14 24 42·0	16 53·15		
				+4·52					+4·86	+5·04
Sep.										
2 0	10 47 52·0	23 57 31·0	−18 40·45							
				+4·68					+4·86	+4·68
4 3					4 20 41·0	−18 30·15	14 40 30·0	16 52·21		
				+4·68					+5·24	+4·68
6 0	11 50 45·5	0 44 15·4	−18 21·54							
				+5·58					+5·24	+5·80
8 3					2 47 7·0	−18 9·79	13 24 40·0	16 52·03		
				+5·58					+5·66	+5·36
10 1	13 17 13·0	1 54 26·2	−17 58·86							
				+5·13					+5·66	+5·96
12 4					5 26 18·2	−17 47·75	16 19 51·0	16 50·83		
				+5·13						+4·30
14 0	11 43 58·0	0 5 25·8	−17 38·66							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·03 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer Z.

Comparisons at Kingstown.					Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 32 57·0	4 34 56·6	−21 39·75							
				+1·33			(Chron. 2306.)			+1·40
7 4					5 0 15·8	−21 37·05	13 26 41·0	16 51·36		
				+1·33					+1·29	+1·26
9 0	10 13 58·0	1 0 42·6	−21 34·64				(Chron. 2306.)			
				+2·33					+1·29	+1·32
11 3					4 51 19·0	−21 29·56	13 33 25·0	16 53·71		
				+2·33					+3·70	+3·34
13 0	10 33 30·5	1 4 19·8	−21 25·28				(Transit Clock)			
				+2·58					+3·70	+4·06
15 2					2 44 26·2	−21 19·86	11 42 3·0	16 48·96		
				+2·58					+0·95	+1·10
17 1	11 35 7·5	1 49 54·2	−21 14·83							
				+1·35					+0·95	+0·80
19 3					4 43 11·0	−21 11·95	13 56 49·0	16 52·99		
				+1·35					+1·65	+1·90
21 1	12 29 9·0	2 28 1·8	−21 9·40							
				+1·79					+1·65	+1·40
23 2					2 58 11·0	−21 5·75	12 27 16·0	16 52·70		
				+1·79					+2·14	+2·18
25 2	13 41 41·5	3 24 34·6	−21 2·17							
				+2·19					+2·14	+2·10
27 3					4 7 25·0	−20 57·69	13 53 28·0	16 52·10		
				+2·19					+2·17	+2·28
29 0	11 28 13·0	0 55 38·2	−20 53·62							
				+2·45					+2·17	+2·06
31 3					4 25 53·0	−20 48·32	14 27 46·0	16 52·77		
				+2·45					+3·18	+2·84
Sep. 2 0	10 50 0·5	0 1 42·6	−20 43·90							
				+2·37					+3·18	+3·52
4 3					4 28 45·0	−20 38·70	14 46 29·0	16 49·62		
				+2·37					+1·16	+1·22
6 0	11 52 45·0	0 48 27·4	−20 34·36							
				+1·61					+1·16	+1·10
8 3					2 54 10·2	−20 30·97	13 29 22·0	16 52·82		
				+1·61					+2·05	+2·12
10 1	13 19 58·5	1 59 40·2	−20 27·81							
				+1·77					+2·05	+1·98
12 4					5 33 48·2	−20 23·99	16 24 45·0	16 51·40		
				+1·77						+1·56
14 0	11 46 27·0	0 10 36·6	−20 20·87							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 51ˢ·83 West.

Chronometer *a*.

Aug. 5 4	13 35 16·0	4 41 8·6	−25 33·13							
				+3·48			(Chron. 2306.)			+3·76
7 4					5 7 35·0	−25 26·01	13 30 12·0	16 51·17		
				+3·48					+3·39	+3·20
9 0	10 16 8·5	1 6 37·8	−25 19·69				(Chron. 2306.)			
				+3·67					+3·39	+3·58
11 3					4 57 7·02	−25 11·71	13 35 33·0	16 51·93		
				+3·67					+3·50	+3·76
13 0	10 35 13·5	1 9 42·2	−25 4·96				(Transit Clock)			
				+3·08					+3·50	+3·24
15 2					2 55 2·2	−24 58·49	11 48 59·0	16 51·45		
				+3·08					+2·98	+2·92
17 1	11 36 18·0	1 54 42·2	−24 52·52							
				+3·90					+2·98	+3·04
19 3					4 50 34·2	−24 44·19	14 0 40·0	16 53·59		
				+3·90					+4·67	+4·76
21 1	12 31 11·5	2 33 31·4	−24 36·84							
				+3·87					+4·67	+4·58
23 2					3 5 11·37	−24 28·94	12 30 56·0	16 50·49		
				+3·87					+3·28	+3·16
25 2	13 43 5·5	3 29 17·4	−24 21·21							
				+3·22					+3·28	+3·40

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER *a.—concluded.*

Comparisons at Kingstown.						Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by ½ Σ.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.		Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s		h m s	m s	h m s	m s	s	s
27 3					+3·22	4 12 39·0	−24 14·61	13 55 26·0	16 51·51		
29 0	11 30 11·5	1 0 51·4	−24 8·65		+3·93					+3·24	+3·04
31 3						4 33 1·4	−24 0·13	14 31 43·0	16 53·00	+3·24	+3·44
Sep.				+3·93						+4·07	+4·42
2 0	10 52 10·5	0 7 1·4	−23 53·05		+4·15					+4·07	+3·72
4 3						4 34 47·0	−23 43·92	14 49 23·0	16 52·89	+4·16	+4·58
6 0	11 55 23·5	0 54 7·4	−23 36·29		+4·15					+4·16	+3·74
8 3					+3·66	3 2 3·0	−23 28·60	13 34 19·0	16 51·79	+3. 87	+3·58
10 1	13 21 23·5	2 3 58·6	−23 21·45		+3·66					+3·87	+4·16
12 4					+3·47	5 44 17·0	−23 13·91	16 32 26·0	16 50·52		+2·78
14 0	11 49 2·5	0 15 58·6	−23 7·79		+3·47						

Concluded Longitude of Valentia from Kingstown = 16m 51s·86 West.

CHRONOMETER *b.*

Aug. 5 4	13 36 18·0	4 39 9·4	−22 32·09								
7 4				+3·00							+3·19
9 0	10 19 11·0	1 6 40·6	−22 20·49		5 6 19·4	−22 25·95	(Chron. 2306.) 13 31 56·0	16 51·92			
11 3				+3·00					+3·22	+2·81	
13 0	10 37 42·5	1 9 12·2	−22 6·37						+3·22	+3·63	
15 2				+3·52	5 0 10·87	−22 12·83	(Chron. 2306.) 13 41 36·5	16 52·15			
17 1	11 38 15·0	1 53 36·6	−21 50·24						+3·69	+3·41	
19 3				+3·52					+3·69	+3·97	
21 1	12 33 32·5	2 32 49·8	−21 34·62		2 59 12·6	−21 57·99	(Transit Clock) 11 56 10·0	16 52·53			
23 2				+4·00					+4·02	+4·03	
25 2	13 45 3·5	3 28 13·4	−21 19·52						+4·02	+4·01	
27 3				+4·00	4 50 25·0	−21 41·94	14 3 35·0	16 52·10			
29 0	11 32 30·0	1 0 5·4	−21 4·53						+3·68	+3·75	
31 3				+3·88					+3·68	+3·61	
Sep.					3 12 47·75	−21 26·96	12 41 34·0	16 52·58			
2 0	10 54 37·5	0 6 23·0	−20 48·06						+3·84	+3·89	
4 3				+3·88					+3·84	+3·79	
6 0	11 56 46·0	0 52 26·2	−20 32·81		4 51 29·0	−21 11·56	14 37 25·0	16 52·36			
8 3				+3·75					+4·07	+3·91	
10 1	13 24 20·5	2 3 53·0	−20 19·33						+4·07	+4·23	
12 4				+3·75	4 35 43·0	−20 55·55	14 37 31·0	16 52·13			
14 0	11 50 50·5	0 14 49·0	−20 10·48						+3·93	+4·07	
				+3·85					+3·93	+3·79	
					4 32 41·0	−20 39·74	14 50 22·0	16 52·22			
				+3·85					+3·71	+3·77	
					3 4 35·0	−20 25·82	13 39 55·0	16 51·48			
				+4·15					+3·71	+3·65	
									+2·37	+3·01	
				+4·15	4 35 43·0	−20 55·55	14 37 31·0	16 52·13	+2·37	+1·73	
				+3·78						+2·79	
					4 32 41·0	−20 39·74	14 50 22·0	16 52·22			
				+3·78							
					3 4 35·0	−20 25·82	13 39 55·0	16 51·48			
				+3·33							
				+3·33							
				+2·26	5 42 25·0	−20 14·44	16 33 31·0	16 53·17			
				+2·26							

Concluded Longitude of Valentia from Kingstown = 16m 52s·27 West.

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

Chronometer *d.*

Comparisons at Kingstown.				Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
5 4	13 39 1·5	4 38 28·13	−19 7·77				(Chron. 2306.)			
				+4·20	5 6 9·0	−18 59·23	13 35 12·0	16 52·77		
7 4				+4·20						
9 0	10 21 12·0	1 5 12·37	−18 51·59				(Chron. 2306.)			
11 3					5 19 51·0	−24 41·16	13 58 51·5	16 51·75		
									+5·35	+5·06
13 0	10 41 5·0	1 14 58·87	−24 31·08				(TransitClock)		+5·35	+5·64
				+5·55	3 11 7·46	−24 19·40	12 5 45·0	16 52·53		
15 2				+5·55					+5·15	+5·46
17 1	11 40 51·5	1 58 31·12	−24 8·69						+5·15	+4·84
				+4·80	4 54 55·5	−23 58·44	14 5 49·0	16 52·47		
19 3				+4·80					+4·81	+4·76
21 1	12 35 59·5	2 37 31·13	−23 49·35						+4·81	+4·86
				+5·39	3 22 45·0	−23 38·27	12 49 20·0	16 53·77		
23 2				+5·39					+5·45	+5·92
25 2	13 48 37·0	3 33 54·38	−23 27·59						+5·45	+4·98
				+5·30	4 56 1·5	−23 16·61	14 39 52·0	16 53·23		
27 3				+5·30					+6·29	+5·62
29 0	11 35 44·5	1 5 21·75	−23 6·90						+6·29	+6·96
				+6·52	4 40 46·5	−22 52·75	14 40 38·0	16 51·93		
31 3				+6·52					+5·98	+6·08
Sep.										
2 0	10 57 13·0	0 10 51·0	−22 40·99						+5·98	+5·88
				+5·85	4 36 46·5	−22 28·12	14 52 39·0	16 52·71		
4 3				+5·85					+6·05	+5·82
6 0	12 0 3·5	0 57 27·75	−22 17·40						+6·05	+6·28
				+5·70	3 10 6·0	−22 5·32	13 43 47·0	16 51·62		
8 3				+5·70					+4·87	+5·12
10 1	13 26 35·0	2 7 42·0	−21 54·20						+4·87	+4·62
				+5·08	5 48 49·5	−21 43·20	16 38 27·0	16 53·73		
12 4				+5·08						+5·54
14 0	11 54 48·5	0 20 10·13	−21 34·26							

Concluded Longitude of Valentia from Kingstown = $16^m\ 52^s\cdot71$ West.

Chronometer *e.*

Aug.										
5 4	13 40 24·5	4 44 45·37	−24 2·23							
				−2·77			(Chron. 2306.)			−2·27
7 4				−2·77	5 13 39·0	−24 7·90	13 37 36·0	16 50·48	−3·58	−3·27
9 0	10 24 3·5	1 13 24·75	−24 12·94				(Chron. 2306.)			
				−3·78					−3·58	−3·89
11 3				−3·78	5 21 39·0	−24 21·23	14 1 0·0	16 51·53	−3·31	−3·67
13 0	10 44 7·0	1 17 57·37	−24 28·08				(TransitClock)			
				−3·35					−3·31	−2·95
15 2				−3·35	3 18 57·0	−24 35·15	12 13 22·0	16 50·56	−3·72	−3·75
17 1	11 42 51·5	2 1 3·75	−24 41·64							
				−3·87					−3·72	−3·69
19 3				−3·87	5 4 57·0	−24 49·91	14 15 2·0	16 50·99	−4·55	−4·05
21 1	12 38 16·0	2 40 55·12	−24 57·22							
				−4·70					−4·55	−5·05
23 2				−4·70	3 28 50·98	−25 6·86	12 54 0·0	16 51·92	−4·89	−4·35
25 2	13 50 4·0	3 37 9·75	−25 16·19							
				−5·52					−4·89	−5·43

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COMPARISON OF TRAVELLING CHRONOMETERS FOR THE LONGITUDE OF VALENTIA FROM KINGSTOWN.

CHRONOMETER *e.—concluded.*

Comparisons at Kingstown.				Comparisons at Valentia.					
Approximate Solar Time, 1844.	Time by $\frac{1}{2}\Sigma$.	Corresponding Time by Chronometer.	Chronometer Slow.	Chronometer's App. Losing Rate.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Chronometer's Apparent Losing Rate.	Chronometer's Adopted Losing Rate.
Aug. d h	h m s	h m s	m s	s	h m s	m s	h m s	m s	s	s
27 3					5 0 18·0	−25 27·62	14 42 0·0	16 51·06		
				−5·52					−4·37	−5·61
29 0	11 37 38·0	1 9 45·75	−25 37·70							
				−2·15					−4·37	−3·13
31 3					4 46 16·5	−25 42·39	14 43 17·0	16 53·73		
Sep.				−2·15					−1·67	−1·17
2 0	10 59 41·5	0 16 24·37	−25 46·26							
				−1·83					−1·67	−2·17
4 3					4 42 57·0	−25 50·29	14 55 28·0	16 52·50		
				−1·83					−1·52	−1·49
6 0	12 1 33·5	1 2 33·75	−25 53·64							
				−2·53					−1·52	−1·55
8 3					3 16 4·5	−25 58·98	13 45 54·0	16 49·79		
				−2·53					−3·48	−3·51
10 1	13 29 32·5	2 14 48·75	−26 3·92							
				−3·36					−3·48	−3·45
12 4					5 57 39·0	−26 11·22	16 42 51·0	16 51·91		
				−3·36						−3·27
14 0	11 56 57·0	0 27 1·12	−26 17·10							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 51ˢ·50 West.

CHRONOMETER *f.*

Aug.										
5 4	13 42 43·5	4 50 55·12	−27 53·37							
				−2·22						−2·02
7 4					5 20 51·0	−27 57·89	(Chron. 2306.) 13 40 57·0	16 52·04		
				−2·22					−2·52	−2·42
9 0	10 25 29·0	1 18 39·0	−28 1·92							
				−2·27			(Chron 2306.)		−2·52	−2·62
11 3					5 32 12·20	−28 6·90	14 7 47·0	16 53·14		
				−2·27					−2·26	−1·92
13 0	10 50 37·5	1 28 9·75	−28 11·03							
				−2·83			(TransitClock)		−2·26	−2·60
15 2					3 26 40·5	−28 16·99	12 17 23·0	16 51·88		
				−2·83					−2·83	−3·06
17 1	11 50 52·5	2 12 44·25	−28 22·47							
				−2·98					−2·83	−2·60
19 3					5 11 36·0	−28 28·85	14 18 2·0	16 51·53		
				−2·98					−3·12	−3·36
21 1	12 42 6·0	2 48 21·75	−28 34·47							
				−3·03					−3·12	−2·88
23 2					3 43 42·0	−28 40·65	13 5 19·0	16 51·98		
				−3·03					−3·18	−3·18
25 2	13 56 7·5	3 46 42·73	−28 46·67							
				−3·23					−3·18	−3·18
27 3					5 6 16·5	−28 53·39	14 44 32·0	16 52·20		
				−3·23					−3·45	−3·28
29 0	11 39 41·5	1 15 10·5	−28 59·29							
				−3·60					−3·45	−3·62
31 3					4 51 7·5	−29 7·13	14 44 45·0	16 52·22		
Sep.				−3·60					−3·53	−3·58
2 0	11 2 25·5	0 22 35·25	−29 13·59							
				−3·36					−3·53	−3·48
4 3					4 50 33·0	−29 21·02	14 59 34·0	16 52·44		
				−3·36					−3·26	−3·24
6 0	12 4 39·5	1 9 12·75	−29 27·16							
				−3·40					−3·26	−3·28
8 3					3 23 1·5	−29 34·36	13 49 14·0	16 51·96		
				−3·40					−3·82	−3·52
10 1	13 32 59·0	2 21 51·75	−29 40·99							
				−3·92					−3·82	−4·12
12 4					6 4 7·5	−29 49·50	16 45 41·0	16 52·59		
				−3·92						−3·72
14 0	11 58 31·5	0 32 14·63	−29 56·36							

Concluded Longitude of Valentia from Kingstown = 16ᵐ 52ˢ·29 West.

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The following Table contains the Results from all the Chronometers.

Reference to Chronometer.	Longitude of Valentia West of Kingstown.	Sum of Squares of Changes of Rate.	Weight of Result.
	m s		
A	16 52·06	1·7012	588
B	52·13	4·1668	240
C	52·00	5·1228	195
D	52·42	2·4680	405
E	52·12	5·2120	192
F	52·32	4·3728	229
G	52·16	4·6880	213
H	51·76	3·6000	278
I	52·26	0·9824	1018
J	52·14	1·9200	521
K	52·03	5·3201	188
K'	51·94	8·3760	119
M	51·77	5·1180	195
N	51·89	5·1648	194
O	51·85	3·8380	261
P	51·27	2·4576	407
Q	52·15	21·6236	46
R	52·41	8·1112	123
S	53·24	34·2444	18
T	51·96	5·1628	194
U	51·69	4·9412	202
W	51·79	2·2080	453
X	51·87	2·5008	400
Y	52·03	10·0800	99
Z	51·83	23·2408	43
a	51·86	11·3940	88
b	52·27	4·7656	210
d	52·71	8·4576	79
e	51·50	20·7488	48
f	52·29	3·2476	308

The sum of weights is 7554

The result for the Longitude of the Valentia temporary Observatory, West of the Kingstown temporary Observatory, is ..... } $16^m\ 52^s\cdot034$

The probable error of this determination, as depending on the unsteadiness of rate of the travelling chronometers, is ..... } $\pm\ 0^s\cdot0129$

This determination is based upon Kingstown transits as observed by Mr. Hind, and Valentia transits as observed by Lieutenant Gosset; and no correction is yet applied for personal equation.

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The following Comparisons, made at Valentia, were not used for the Determination of Longitude; but they are used in the next Section, for the Determination of the Stationary Rates of the Travelling Chronometers at Valentia.

Reference to Chrono-meter.	Comparisons near August 26, 14h.				Comparisons near September 3, 13h.			
	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.	Time by Chronometer.	Chronometer Error employed.	Corresponding Time by Valentia Transit Clock.	Resulting Difference of Longitude.
	h m s	m s	h m s	m s	h m s	m s	h m s	m s
A	14 26 0·0	−23 20·27	0 7 26	16 52·41	13 41 48·0	−23 13·01	23 54 31	16 51·34
B	14 20 0·0	−13 17·79	0 11 30	16 51·57	13 34 22·4	−12 32·95	23 57 46	16 51·32
C	14 25 42·0	−17 52·07	0 12 37	16 52·46	13 42 42·03	−17 24·09	0 1 15	16 51·39
D	14 31 28·4	−19 49·99	0 16 26	16 52·55	13 50 14·4	−19 8·89	0 7 3	16 51·90
E	14 41 11·2	−24 25·22	0 21 35	16 51·95	13 59 19·2	−24 24·00	0 10 54	16 51·20
F	14 46 2·0	−22 3·75	0 28 49	16 51·40	13 59 54·0	−21 54·40	0 13 59	16 51·11
G	14 46 30·0	−20 48·08	0 30 32	16 52·36	14 0 26·4	−20 20·32	0 16 5	16 51·94
H	14 37 35·2	− 9 10·50	0 33 15	16 52·57	13 51 58·0	− 8 17·44	0 19 40	16 51·99
I	14 56 45·2	−22 21·57	0 39 16	16 51·49	14 6 46·0	−22 9·48	0 20 37	16 51·11
J	14 59 4·0	−21 38·77	0 42 18	16 51·58	14 7 57·2	−21 15·13	0 22 42	16 52·00
K	15 5 8·0	−24 21·70	0 45 39	16 52·19	14 14 50·0	−24 3·57	0 26 47	16 52·02
*K**	15 6 21·0	−20 2·63	0 51 11	16 53·16	14 15 24·2	−19 31·26	0 31 54	16 52·36
M	15 12 57·18	−23 58·63	0 53 53	16 51·78	14 24 30·0	−23 58·42	0 36 34	16 51·77
N	15 14 10·0	−22 39·31	0 56 25	16 52·33	14 26 0·0	−22 21·10	0 39 42	16 51·59
O	15 8 51·6	− 9 54·42	1 3 53	16 52·03	14 17 20·4	− 9 29·98	0 43 54	16 51·80
P	15 38 34·0	−35 57·35	1 7 33	16 52·10	14 54 21·2	−36 40·67	0 53 46	16 51·51
Q	15 29 20·4	−22 2·37	1 12 14	16 53·24	14 42 17·2	−21 52·32	0 56 32	16 50·31
R	15 38 15·2	−26 22·76	1 16 50	16 52·39	14 54 30·8	−25 33·70	1 5 4	16 51·92
S	15 35 8·0	−15 28·96	1 24 38	16 52·27	14 45 14·0	−14 44·10	1 6 34	16 54·97
T	15 51 45·2	−24 34·99	1 32 11	16 51·66	14 56 45·98	−25 12·96	1 7 41	16 51·26
U	15 48 32·0	−18 4·97	1 35 28	16 52·01	14 55 20·4	−17 28·69	1 13 59	16 52·98
W	16 12 48·2	−38 9·94	1 39 40	16 51·92	15 20 55·0	−39 9·19	1 17 55	16 51·72
X	16 3 11·0	−25 25·26	1 42 48	16 51·92	15 12 26·6	−25 34·13	1 23 2	16 52·21
Y	16 0 30·2	−19 6·75	1 46 26	16 52·21	15 9 15·38	−18 32·74	1 26 53	16 52·00
Z	16 5 29·0	−20 58·79	1 49 34	16 51·48	15 16 42·18	−20 40·00	1 32 16	16 49·42
a	16 13 16·2	−24 16·23	1 54 5	16 50·96	15 21 49·0	−23 46·19	1 34 15	16 51·36
b	16 13 28·0	−21 13·56	1 57 20	16 50·97	15 22 49·4	−20 41·82	1 38 20	16 51·81
d	16 20 24·0	−23 19·39	2 2 10	16 51·92	15 30 27·0	−22 31·31	1 44 10	16 50·86
e	16 24 45·0	−25 24·74	2 4 26	16 51·94	15 35 16·5	−25 49·28	1 45 41	16 51·64
f	16 31 40·5	−28 51·71	2 7 56	16 51·04	15 43 6·0	−29 19·18	1 50 2	16 50·95

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XIII. — *Difference between Travelling Rates and Stationary Rates of Travelling Chronometers; Correction of the determination of Longitude for this difference; Combination of the various Differences of Longitude; Corrections for Personal Equation of Transit-Observers; and final result for Astronomical Difference of Longitude.*

In the comparisons for determining the longitude of Liverpool as referred to Greenwich, there are six independent determinations of stationary rates of travelling chronometers. The mean of these has been compared with the mean of all the travelling rates during the same operation.

In the comparisons for determining the longitude of Kingstown, as referred immediately to Greenwich, there are seven independent determinations (of which one is used twice) of stationary rates. The mean of these has been compared with the mean of all the travelling rates during that operation.

Between the operation for connecting Kingstown with Liverpool, and that for connecting Kingstown with Valentia, one stationary rate is obtained (August 4, 3^h to 5, 4^h). This is compared with the mean of the last of the Kingstown-Liverpool mixed rates and the first of the Kingstown-Valentia mixed rates.

At Valentia, stationary rates were obtained between August 26, 14^h and 27, 3^h, and between Sep. 3, 13^h and Sep. 4, 3^h. These are compared with the mean of the mixed rates immediately preceding and following them.

The subjoined table contains the results:—

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Excess of Chronometer's Stationary Rate above its Travelling Rate, the Rates being estimated positive when losing.

Reference to Chronometer.	In Comparisons between Greenwich and Liverpool.	In Comparisons between Greenwich and Kingstown.	At Kingstown.	At Valentia.
	s	s	s	s
A	+0·32	+0·05	−0·42	−0·33
B	−1·13	−2·41	+3·18	−1·40
C	+1·31	+0·33	−0·40	−0·14
D	−1·50	−0·45	−1·60	−0·72
E	−0·16	−1·66	+0·34	−1·31
F	−1·55	−1·15	−1·10	−2·52
G	+0·41	−0·37	+0·20	−0·49
H	−0·13	−1·15	−1·03	+0·32
I	−1·74	−0·77	−0·15	−1·91
J	−1·00	−0·95	−0·20	−0·62
K	−0·96	−0·46	−1·70	−0·76
*K**	+0·60		−1·71	+0·45
L		+0·12		
M	+0·31	+0·15	−0·63	−0·18
N	−0·47	−0·43	−1·27	−0·35
O	+0·47	−1·69	+0·76	−0·20
P	−0·89	−0·73	−0·21	+0·75
Q	+1·31	−1·34	−0·60	−0·67
R	+0·49	−3·74	−1·88	−0·69
S	−0·63	−1·83	−2·97	−1·89
T	+0·32	−0·07	+0·29	−0·15
U	+0·47	+0·11	−1·27	+0·55
W	+0·43	−0·01	−0·57	−0·16
X	+0·40	+0·07	−0·12	+0·26
Y	−0·38	−0·66	−1·54	−1·12
Z	−0·24	−1·24	+0·98	−0·80
a	−2·85	−1·88	−2·71	−1·94
b	−1·15	−1·21	−0·60	−1·72
d	+0·75	+0·23		−1·95
e	+0·66	−0·08	+0·24	+0·06
f	−1·85	−0·83	−0·65	−2·46
Mean..	−0·28	−0·80	−0·58	−0·73
Weights	6	8	1	2
General Mean	.....	.....	−0s·60	

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As, in most of these instances, the stationary rate is compared not with a pure travelling rate but with a mixed rate, the result ought to be somewhat increased. Thus we may state, as a result of these comparisons, that the effect of travelling is to make pocket chronometers lose about $0^s{\cdot}7$ per day. In the following applications of corrections to the longitude, I have used the quantity $0^s{\cdot}6$ without increase, as the rates which are supposed unaltered are partially mixed rates.

1. No correction is to be made in the longitude of Liverpool as referred to Greenwich; the stationary rates being fully taken into account.

2. In computing the longitude of Liverpool as referred to Kingstown, the mean interval from Kingstown comparison to Liverpool comparison was $19\frac{1}{4}$ hours, and that from Liverpool comparison to Kingstown comparison was $28\frac{1}{4}$ hours. Let r be the mixed rate for $19\frac{1}{4}$ hours, $r - 0^s{\cdot}60$ the stationary rate for 9 hours, and r the mixed rate for the remaining $19\frac{1}{4}$ hours. Then the whole loss is $2r - 0^s{\cdot}60 \times \frac{9}{24}$; and the proportional part of this for $19\frac{1}{4}$ hours is

$$\frac{19\frac{1}{2}}{24} r - \frac{19\frac{1}{2}}{48} \times 0^s{\cdot}225;$$

which is the quantity that we may conceive to have been used in the previous operations. But the quantity which ought to have been used is $\frac{19\frac{1}{2}}{24} r$. Therefore the correction, which ought to be applied to the chronometer's loss is,

$$\frac{19\frac{1}{2}}{48} \times 0^s{\cdot}225, \text{ or } 0^s{\cdot}091.$$

By this quantity, the Kingstown sidereal time at Liverpool comparison will be increased; and therefore the difference of longitude will be diminished.

3. In computing the longitude of Kingstown as referred to Greenwich, it was assumed that the journey from Greenwich to Kingstown occupied 24 hours, and that from Kingstown to Greenwich 27 hours. Yet it is probable that the actual agitation by the journey occupied no longer time in the latter passage than in the former. Thus estimated, the whole loss in the two journeys was

$$2r + \frac{1}{8}(r - 0^s{\cdot}60) = \frac{51}{24} r - 0^s{\cdot}075;$$

the proportional part of which for 24 hours is $r - 0^s{\cdot}035$; and this has been

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used. But the quantity which ought to have been used is r. Therefore, the correction to be applied to the Greenwich sidereal times at the Kingstown comparisons is $+0^s{\cdot}035$; and by this quantity the difference of longitude will be increased.

4. In computing the longitude of Valentia, as referred to Kingstown, the interval from Kingstown comparison to Valentia comparison was supposed 49¼ hours, and that from Valentia comparison to Kingstown comparison was 46¼ hours. The correction, computed in the same way, is $0^s{\cdot}042$, by which the difference of longitude is to be diminished.

Applying these corrections to the results formerly obtained, we have the following (still requiring correction for personal equation of transit-observers):—

	m	s
Longitude West from Greenwich to Liverpool	11	59·886
„ „ Liverpool to Kingstown	12	31·322
Hence from Greenwich to Kingstown, by indirect or composite determination, is	24	31·208
From Greenwich to Kingstown, by direct determination, is	24	31·097
From Kingstown to Valentia	16	51·992

The difference between the two determinations of the longitude of Kingstown, although very small, namely, $0^s{\cdot}111$, is greater than the preceding numbers would abstractedly have led us to expect. The probable error in the Greenwich-Liverpool determination being $0^s{\cdot}010$, and that in the Liverpool-Kingstown determination being $0^s{\cdot}016$, the probable error of the composite Greenwich-Kingstown will be $0^s{\cdot}019$. And as the probable error of the direct determination is $0^s{\cdot}014$, the probable discordance of the two is $0^s{\cdot}024$. This, it is to be remarked, is the probable discordance depending only upon the unsteadiness of the travelling or mixed rates of the chronometers as used in the four last sections, and does not include any uncertainty depending on the uncertainty of the chronometers' stationary rates, or on the errors in the astronomical determinations, or on the possible change in the habits of the transit-observer. It seems not unreasonable to attribute the principal part of the difference of determinations to these latter causes.

In a case like this, where the only calculation of probable errors that we can make evidently does not apply to the principal causes of error, the

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adoption of final results must be somewhat arbitrary. Remarking, however, the favourable circumstances of comparison in the Greenwich-Liverpool determination, the duration and generally favourable circumstances of the Greenwich-Kingstown determination, and the smaller duration and less favourable circumstances of comparison in the Kingstown-Liverpool determination, I think that the two former may be altered by equal quantities, $0^s{\cdot}028$, and the third by double that quantity, or $0^s{\cdot}055$. Thus we have,

	m	s
Liverpool, West of Greenwich	11	59·858
Kingstown, West of Liverpool	12	31·267
Kingstown, West of Greenwich	24	31·125
The probable error of which does not perhaps exceed		0·03

Combining with this the result,

Valentia, West of Kingstown	16	51·992

We have

Valentia, West of Greenwich	41	23·117
With a probable error perhaps of	$0^s{\cdot}04$, or	0·05

These results are founded upon transit-observations as made by Mr. Henry, at Greenwich; by Mr. Hartnup, at Liverpool; by Mr. Hind, at Kingstown; and by Lieutenant Gosset, at Valentia. They are yet subject to the correction for the personal equation or difference in the mode of observing transits among these observers; and I now proceed to give the elements of that correction.

On 1844, December 5, fourteen stars were observed by Mr. Sheepshanks, with the transit instrument of the Royal Observatory, Greenwich; and their places were corrected by the clock-errors determined from Mr. Henry's observations of ten clock stars, compared with the places in the Greenwich Catalogue of 1439 Stars (slightly altered from some observations in 1843). Mr. Sheepshanks' places of the fourteen stars thus obtained were compared with the places of the same stars in the Greenwich Catalogue.

The following table contains the whole operation:—

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DETERMINATION OF PERSONAL EQUATION BETWEEN MR. SHEEPSHANKS AND MR. HENRY.

Month and Day, 1844.	Star's Name.	Observer.	Number of Wires.	Transit over Mean of the Seven Wires.	Seconds corrected for instrumental Errors.	Tabular R.A. of Clock-Stars.	Clock apparently Slow.	Deduced Apparent Right Ascension.	Deduced Mean Right Asc.	Mean R.A. of Greenwich Cat.	Excess of the former.
				h m s	s	s	s	h m s	s	s	s
Dec. 4	Arcturus....	H	4	14 8 20.32	20·34	35·01	14·67				
	ϵ Bootis	H	7	14 37 57·42	57·43	12·23	14·80				
	α Coronæ...	H	7	15 27 51·93	51·94	6·56	14·62				
	α Serpentis..	H	7	15 36 22·84	22·84	37·46	14·62				
Dec. 5	α Lyræ.....	H	7	18 31 25·56	25·57	40·24	14·67				
	β Lyræ.....	H	7	18 44 5·72	5·74	20·47	14·73				
	θ Pegasi....	S	1	22 2 7·93	7·93			22 2 22·73	19·36	19·66	—0·30
	θ Aquarii ...	S	6	22 8 24·09	24·08			22 8 38·88	35·34	35·73	—0·39
	γ Aquarii ...	S	6	22 13 24·07	24·06			22 13 38·86	35·35	35·69	—0·34
	ζ Aquarii....	S	7	22 20 36·13	36·12			22 20 50·93	47·39	47·62	—0·23
	σ Aquarii....	S	6	22 22 11·47	11·45			22 22 26·26	22·63	23·10	—0·47
	η Aquarii....	S	7	22 27 8·60	8·59			22 27 23·40	19·83	20·19	—0·36
	κ Aquarii ...	S	7	22 29 28·84	28·83			22 29 43·64	40·02	40·40	—0·38
	ζ Pegasi....	S	7	22 33 29·19	29·19			22 33 44·00	40·45	40·96	—0·51
	τ^2 Aquarii...	S	7	22 41 8·07	8·05			22 41 22·86	19·01	19·56	—0·55
	λ Aquarii ...	S	7	22 44 16·88	16·87			22 44 31·69	27·98	28·28	—0·30
	δ Aquarii ...	S	7	22 46 10·30	10·28			22 46 25·10	21·34	21·77	—0·43
	Fomalhaut..	S	7	22 48 49·40	49·36			22 49 4·18	0·35	0·93	—0·58
	3 Piscium...	S	4	22 52 26·32	26·31			22 52 41·13	37·40	37·78	—0·38
	α Pegasi....	S	7	22 56 48·07	48·08			22 56 62·90	59·20	59·64	—0·44
	α Andromedæ	H	7	0 0 9·50	9·51	24·30	14·79				
	γ Pegasi....	H	7	0 5 1·84	1·85	16·66	14·81				
	β Ceti.....	H	7	0 35 34·67	34·66	49·41	14·75				
	θ Ceti.....	H	7	1 16 3·00	2·99	17·99	15·00				

Mean..... — 0ˢ·404

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It appears from this that Mr. Sheepshanks writes down a smaller number for the star's time of transit, and therefore makes the "clock slow" greater than Mr. Henry does, by $0^s{\cdot}404$. Expressing this, therefore, by our usual equation, in which the initial of the observer's name is used to denote the "clock slow" resulting from his observation,

$$S - He = +\,0^s{\cdot}404.$$

For the personal equation between Mr. Sheepshanks and Mr. Hartnup, fifteen stars were observed by Mr. Sheepshanks, and ten stars by Mr. Hartnup, at the Liverpool Observatory, on 1844, Dec. 6. I am not possessed of the whole of the details of these observations, and therefore state only the following abstract of results:—Six of the stars observed by Mr. Sheepshanks preceded those observed by Mr. Hartnup, and gave for clock slow at the mean epoch of Mr. Hartnup's observations, $22^s{\cdot}23$. The remaining nine stars followed those observed by Mr. Hartnup, and gave for clock slow at the same epoch $22^s{\cdot}35$. The latter stars being the better observed, $22^s{\cdot}31$ is adopted. The mean "clock slow" determined by Mr. Hartnup for the same time is $22^s{\cdot}10$ (the extreme determinations being $21^s{\cdot}95$ and $22^s{\cdot}18$). Hence we have

$$S - Ha = +\,0^s{\cdot}21.$$

Combining this with the preceding determination,

$$Ha - He = +\,0^s{\cdot}19.$$

The "clock slow" used at Liverpool has therefore been too great by $0^s{\cdot}19$. Diminishing it by this quantity, and therefore diminishing the nominal sidereal time at chronometer-comparisons by this quantity, we evidently increase the difference of Greenwich and Liverpool sidereal times, or increase the west longitude of Liverpool. Thus the west longitude of Liverpool already found is to be increased by $0^s{\cdot}19$.

The personal equation between Mr. Sheepshanks and Mr. Hind, as has been explained in Section VI., is given by the equation $S - J.\,H = +\,0^s{\cdot}33$. Combining this with the first equation, we find,

$$J.\,H - He = +\,0^s{\cdot}07;$$

by which quantity the west longitude of Kingstown is to be increased.

The personal equation between Mr. Sheepshanks and Lieutenant Gosset,

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as inferred from the combination of the two equations in Section VI., is S − G = + 0ˢ·29. Combining this with the first equation, we find,

$$G - He = + 0^s \cdot 11;$$

by which quantity the west longitude of Valentia is to be increased.

Applying these corrections we obtain the following final results:—

Longitude of Liverpool West from Greenwich			12ᵐ	0ˢ·05
,,	Kingstown	,,	24	31·20
,,	Valentia	,,	41	23·23

and the probable error of the last determination can scarcely amount to 0ˢ·05 or 0ˢ·06.

It is proper to mention here that, in the adoption of the personal equations above, I have taken the observations bearing on this element which were made at times approaching most nearly to the times of the observations relating to the longitude-determination, and under circumstances most nearly resembling those circumstances. Other observations have been made at different times presenting a somewhat different result. Of these I give the following abstract: the details will be found in the Greenwich Observations.

In the years 1843 and 1844 the clock errors at 0ʰ sidereal as determined from different groups of clock stars observed by Mr. Main and Mr. Hind at the Royal Observatory, Greenwich, were as follows:—

		M.	J. H.	J. H.—M.
1843, August	11	43ˢ·65	43ˢ·54	− 0ˢ·11
,, August	18-19	49·51	49·38	− 0·13
1844, September	24	57·55	57·74	+ 0·19

The mean gives J. H − M. = − 0ˢ·02. As we have reason to believe that the difference between Mr. Main's and Mr. Henry's modes of observation is very small, these observations give J. H. − He = −0ˢ·02.

On 1845, Feb. 6, observations were made by Mr. Henry and Mr. Hind at the Royal Observatory, Greenwich, partly by the observation of broken transits (one observer taking the transit over four wires, and the other over the remaining three wires, and the means being reduced to the mean of the seven wires by the known interval of the wires, the order of observations being also changed,) and partly by observations of groups of different clock stars, the group observed by Mr. Hind being included between two groups observed by Mr. Henry. The results are—

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By broken transits of four stars	J. H − He = + 0·13
By clock errors of five stars observed by Mr. Hind compared with fourteen stars observed by Mr. Henry	J. H − He = − 0·15

I can give no explanation of the discordance between the two last results, or of that between the last result and the result of comparisons through Mr. Sheepshanks.

For the personal equation of Lieutenant Gosset, observations were made on 1844, April 1, 2, 3, 4, 6. On April 1 and 3 they were compared with Mr. Ellis's observations, which were reduced to Mr. Henry's by the application of the well-established difference − 0ˢ·30 to the clock-errors determined by Mr. Ellis. The results of the five days for the quantity of G − He are,

$$+ 0^s\cdot31,\ + 0^s\cdot22,\ + 0^s\cdot31,\ + 0^s\cdot28,\ + 0^s\cdot34;$$

the mean gives,

$$G - He = + 0^s\cdot30$$

It will be remarked that Lieutenant Gosset was at this time unaccustomed to observation with a transit instrument, and that a change in his method of observation is sufficiently probable.

I do not think that these discordances offer any reason for changing the values already adopted, or that they leave any material doubt on the correctness of the results concluded from those adopted values. But they tend to shew that the proportion of uncertainty as depending on personal equation to uncertainty as depending on transmission of chronometers is greater than is generally supposed.

It is also proper to state that, in the reduction of the Greenwich Observations for 1844, an error was committed, arising from this circumstance: that in preparing the places of several clock stars, the results of the year 1842 (which were referred to the old equinox) were combined unaltered with the results of the year 1843 (which were referred to the same equinox as the Greenwich Catalogue of 1439 Stars). I have satisfied myself by examination of the instances affected by this error, that the error of results must be much below $\frac{1}{100}$ of a second of time. The only star which could produce sensible error is θ Ceti in the determination of Mr. Sheepshanks' personal equation; but in this instance I have corrected the place of the star, and the error is entirely removed.

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XIV.—*Computation of the Geodetic Values of the Differences of Longitude upon Assumed Elements for the Figure of the Earth; Comparison of the Geodetic Value with the Chronometrical Value; and Final Result for the Value of an Arc of Parallel.*

In comparing a difference of longitude determined by transmission of chronometers, by observations of reciprocal azimuths, or by any other means, with the results of a geodetic survey connecting the two extreme points: if the extent of the arc be small, the easiest method of instituting the comparison in such a form as to give information upon the dimensions of the earth is—to convert the geodetic measure into chord-distance or arc-distance between the extreme points; from this to find the chord-distance or arc-distance between two points in the same parallel; and, by a small correction, to obtain the distance between these two points as measured along the parallel. But this method cannot be applied where the difference of longitude is so great as in the instance before us (in which it exceeds ten degrees). The only method that here appears practicable is analogous to that which is adopted in regard to widely-separated observations of planets, comets, &c. The elements being very approximately known, the place or measure is to be computed from these approximate elements, and this computed number is to be compared with that found from observation. If it agrees exactly, the elements (in so far as they can be tested by this measure) are correct. If there is discordance, the amount of discordance enables us to compute the amount of error of the elements. The value of this method consists in this, that it is always possible to compute a place from assumed elements with the utmost geometrical accuracy, and thus the comparison between the place obtained from assumed elements, and the place found from observations, may be rigorously exact.

Having satisfied myself that this course of proceeding would be the proper one in reference to the case before me, I requested the assistance of Colonel (now Major-General) Colby for communication of the necessary elements for computing the chain of geodetic lines, connecting the Royal Observatory of Greenwich with the Liverpool Observatory, the temporary Kingstown Observatory, and the station of Feagh Main. Colonel Colby complied with my request with a zeal and liberality which I had no title to expect. He not

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only took immediate steps for connecting, by a secondary triangulation, the Liverpool and Kingstown Observatories with the great triangulation, but he also made many experimental calculations for determining the process which would be best employed in the computation, prepared the materials of every kind, effected the calculations throughout, and, finally, placed the whole at my service. In every part which required more detailed explanation, I received most powerful assistance from Captain Yolland, R.E., who, under Colonel Colby's instructions, superintended the principal part of these computations. The whole of this Section may therefore be considered as the work of Colonel Colby, attached to the chronometrical work for the convenience of comparison of the two sets of results.

The first matter to be determined was, the nature of the formulæ to be used for computing this case: Given the bearing and distance in feet of the second station as viewed from the first, and given also the astronomical latitude of the first station; to compute the astronomical latitude and the difference of longitude of the second station, and the bearing of the first station as viewed from the second. Theorems have been laid down for the computation of similar cases, on the supposition that each of these distances, or geodetic lines, is the shortest line connecting two points on the surface of the spheroid. On this I have only to remark that the supposition is unfounded; the geodetic lines of observation are really straight lines; and we are therefore compelled to resort to other methods, which may appear better adapted to the true circumstances of geodetic observation.

The following are the rigorous theorems upon which a complete system of geodetic trigonometry may be founded:—

If h and k are the major and minor semi-axes of the spheroid, a and b the astronomical colatitudes of two stations, C the difference of longitude, then:—

Cotan. angle of azimuth opposite a =

$$\frac{k^2 . \sin. a . \cos. b - h^2 . \cos. a . \sin. b . \cos. C}{h^2 . \sin. b . \sin. C} + \frac{(h^2 - k^2) . \sin. a . \cos. a}{h^2 . \sin. b . \sin. C} \sqrt{\frac{k^2 . \cos.^2 b + h^2 . \sin.^2 b}{k^2 . \cos.^2 a + h^2 . \sin.^2 a}}$$

Square of the chord-distance between the two stations =

$$\frac{k^4 . \sin.^2 a + h^4 . \cos.^2 a}{h^2 . \cos.^2 a + k^2 . \sin.^2 a} + \frac{h^4 . \sin.^2 b + k^4 . \cos.^2 b}{h^2 . \cos.^2 b + k^2 . \sin.^2 b} - 2 \frac{h^4 . \sin. a . \sin. b . \cos. C + k^4 . \cos. a . \cos. b}{\sqrt{\{k^2 . \cos.^2 a + h^2 . \sin.^2 a\}} \sqrt{\{k^2 . \cos.^2 b + h^2 . \sin.^2 b\}}}$$

These theorems, however, and those which may be derived from them, are too complicated for extensive use.

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Under the direction of Captain Yolland, trials were made of several formulæ for the computation of large geodetic triangles. The triangles selected for this purpose were Precelly, Snowdon, Kippure; and Kippure, Kulteagh, Keeper. In each of these the spherical excess is greater than 49″, and one side at least exceeds 100 miles in length. The test of success was assumed to be that, on starting with an assumed latitude and longitude of one station, and with an assumed azimuth of the second station from the meridian as seen from the first, and using the angles of the triangle which correspond rigorously to the sides of the triangle; and computing, from the the first station, the latitude, longitude, and reciprocal azimuth at the second station, and (by application of the angle of the triangle) obtaining the azimuth of the third station as seen from the second; then computing in like manner from the second to the third; and then from the third to the first; the assumed latitude and longitude of the first station, and the azimuth of the second station at the first, should be rigorously reproduced.

It was found that on using the method introduced by Delambre (of referring all the calculations for any one station to the surface of a sphere whose centre is the point at which the normal to that station meets the axis of revolution), all desirable accuracy was obtained. The latitude and longitude were reproduced without sensible error; the azimuth was reproduced with an error of one or two tenths of a second.

The form in which this method was used was the following. A table was prepared of the length in feet of 1″ for an arc perpendicular to the meridian. Then, the distance of the second station from the first being expressed in feet: this number of feet was converted into seconds of arc by means of the "length of 1″ for an arc perpendicular to the meridian," for the latitude of the first station, whatever the bearing of the second station from the first might be. Then the computation for the latitude, longitude, and reciprocal azimuth at the second station, were computed by the rules of spherical trigonometry; and then, a table of the "length of 1″ for an arc in the meridian" having been prepared, the apparent difference of latitude of the first station and the second was converted into true difference of latitude by multiplying it by the fraction

$$\frac{\text{length of 1″ for an arc perpendicular to meridian at 1st station}}{\text{length of 1″ for an arc in the meridian at latitude intermediate to those of 1st and 2nd stations}},$$

and, applying this true difference of latitude to the latitude of the first station, the latitude of the second station was found. No alteration was made in the longitude or reciprocal azimuth.

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The next point was to determine on the spheroidal elements which should be used. It has been the practice for some years to employ, in the geodetic calculations made in the Ordnance Map-Office under Colonel Colby's direction, the elements which I obtained by an investigation published in the article "Figure of the Earth" in the Encyclopædia Metropolitana. These elements are,

Polar semi-axis.....	20,853,810 feet
Equatoreal.....	20,923,713 „

and the tables computed from them and employed in the geodetic calculations of this Section, are the following:—

Complement of the Logarithm of the Number of Feet in 1".

Latitude.	For Arc perpendicular to the Meridian.	For Arc in the Meridian.
° ′		
50 30	7·9929221	7·9941006
40	29180	40882
50	29137	40754
51 0	29096	40631
10	29055	40508
20	29014	40384
30	28973	40262
40	28932	40138
50	28890	40013
52 0	28849	39889
10	28808	39767
20	28767	39644
30	28727	39523
40	28686	39400
50	28645	39277
53 0	28604	39154
10	28564	39034
20	28523	38911
30	28482	38788
40	28441	38666

The map attached to this paper will shew the lines of triangulation connecting the Royal Observatory of Greenwich with the Observatories of Liverpool, Kingstown, and Feagh Main. And the subjoined table will shew all the principal steps of the calculation. The following explanations, it is hoped, will be sufficient to render the table intelligible:—

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The angles of azimuth are in all cases reckoned in the direction N, E, S, W, N, E.

The zero of absolute azimuth is in all cases the north meridian of the place.

The angle of azimuth in the second column is the horizontal angle between the first and third station as observed with the theodolite planted on the second station.

The log. distance in the third column is computed from the triangulation, of which the details are suppressed here.

The calculations have been made on two suppositions:—In the first, which is distinguished as the *first method*, the absolute azimuth observed at Greenwich is used as far as Wrotham, and then the absolute azimuth observed at Wrotham (by reference to the astronomical meridian as determined by observation of circumpolar stars) is used for the remainder of the chain of geodetic sides. In the *second method*, the absolute azimuths observed at Greenwich, Wrotham, Leith Tower, Butser, and Dunkerry, are successively used.

Absolute azimuths were also observed (for comparison with the computed azimuths) at Dunnose, Wingreen, Mendip, Precelly, Dunstable, White Horse, Arbury, Bardon, Axe Edge, Whittle Hill, Delamere, and Dublin Observatory And absolute latitudes were observed with the zenith sector at Dunnose, Precelly, Hungry Hill, Forth, Feagh Main, Arbury Hill, Delamere; and with the Ramsden's Circle at Dublin Observatory.

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CHAIN OF GEODETIC LINES

Names of Three Successive Stations.	Angle of Azimuth from the First Station to the Third, as seen at the Second.	Log. Distance in Feet from Second Station to Third.
	° ′ ″	
Assumed for Greenwich	.....	.....
North Meridian, Greenwich, Chingford.....	359 59 53·83	4·7622738
Greenwich, Chingford, Severndroog	347 13 46·82	4·8026910
Chingford, Severndroog, Wrotham	149 26 14·71	4·8751369
North Meridian, Greenwich, Norwood	218 7 16·00	4·4952140
Greenwich, Norwood, Severndroog.....	20 15 2·77	4·5928122
Norwood, Severndroog, Wrotham.....	258 17 37·82	4·8751369
North Meridian, Greenwich, Severndroog.....	106 10 35·12	4·1647154
Greenwich, Severndroog, Wrotham.....	210 29 19·47	4·8751369
Greenwich, Chingford, Wrotham.....	330 38 44·45	5·1259313
Adopted for Wrotham.....		
Greenwich, Norwood, Hanger Hill	272 21 21·00	4·8039848
Norwood, Hanger Hill, Leith Tower.....	57 12 26·34	5·1062144
Chingford, Wrotham, Leith Tower	280 32 54·75	5·2008803
Chingford, Severndroog, Leith Tower.....	235 50 21·64	5·1606647
Adopted for Leith Tower		
[Note. From Wrotham and Leith Tower commences the branch chain to Liverpool Observatory.]		
Wrotham, Leith Tower, Butser	171 58 31·81	5·1977346
Leith Tower, Butser, Dunnose	138 44 0·87	5·1480450
[For verification of latitude]		
Leith Tower, Butser, Wingreen.....	208 37 25·78	5·4148029
Butser, Wingreen, Mendip.....	220 20 40·65	5·1192792
Wingreen, Mendip, Dunkerry	135 22 46·90	5·3799736
Mendip, Dunkerry, Precelly	232 21 9·78	5·5949357
Dunkerry, Precelly, Kippure.....	186 51 24·22	5·7542078
[Note. From Kippure commences the branch chain to Kingstown Observatory.]		
Precelly, Kippure, Keeper.....	108 53 6·18	5·6560502
Kippure, Keeper, Bartregaun.....	171 53 15·37	5·6043242
Keeper, Bartregaun, Hungry Hill	117 42 19·83	5·2788759
[For verification of latitude.]		
Keeper, Bartregaun, Feagh Main.....	168 41 25·32	5·1927594
Dunkerry, Precelly, Forth.....	153 8 26·30	5·6271469
Precelly, Forth, Knockanafrion.....	160 2 22·35	5·3587705
Forth, Knockanafrion, Bartregaun.....	180 22 42·78	5·7028291
Knockanafrion, Bartregaun, Hungry Hill	91 45 2·87	5·2788759
[For verification of latitude.]		
Knockanafrion, Bartregaun, Feagh Main.....	142 44 8·36	5·1927594
Adopted for Feagh Main		

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FROM GREENWICH TO FEAGH MAIN.

Computed Azimuth of Second Station from North Meridian, as seen at the Third Station. 1st Method.	2nd Method.	Azimuth Observed.	Computed Latitude of Third Station. 1st Method.	2nd Method.	Latitude Observed.	Computed West Longitude from Greenwich of Third Station. 1st Method.	2nd Method.
° ′ ″	″	″	° ′ ″	″	″	° ′ ″	″
.....			51 28 38·30			.....	
179 59 53·81			51 38 8·85			0 0 0·03	
347 16 34·21			51 27 58·09			−0 3 41·62	
316 53 21·52		21·83	51 18 58·71			−0 17 11·17	
38 3 17·86			51 24 35·50			0 5 4·52	
238 25 12·04			51 27 58·09			−0 3 41·61	
316 53 22·46		21·83	51 18 58·71			−0 17 11·16	
286 13 28·49			51 27 58·09			−0 3 41·61	
316 53 20·57		21·83	51 18 58·71			−0 17 11·17	
330 52 5·02		6·06	51 18 58·72			−0 17 11·17	
			51 18 58·71			−0 17 11·17	
130 14 39·19			51 31 21·96			0 17 51·13	
7 23 42·56		50·65	51 10 32·86			0 22 11·02	
70 54 18·67		23·32	51 10 32·88			0 22 11·02	
42 46 43·76		49·42	51 10 32·87			0 22 11·02	
			51 10 32·88			0 22 11·02	
62 24 24·56	29·19	29·85	50 58 38·21	38·24		0 58 43·74	43·77
20 58 16·06	21·30	21·25	50 37 3·66	3·71	7·10	1 11 50·12	50·19
90 9 15·08	20·37	18·91	50 59 4·73	4·78		2 6 24·85	24·85
130 9 32·42	37·74	33·82	51 13 4·88	4·96		2 32 36·71	36·68
84 43 35·86	41·17	41·91	51 9 44·12	44·27		3 35 8·40	8·38
136 8 56·11	62·26	56·41	51 56 44·84	45·07	44·13	4 46 24·99	24·84
141 46 7·20	13·51		53 10 40·94	41·27		6 19 52·94	52·58
69 6 47·97	54·20		52 45 4·58	5·01		8 15 39·49	39·21
59 45 25·32	31·44		52 12 24·52	25·05		9 49 45·31	45·14
357 29 30·29	36·33		51 41 11·91	12·44	10·06	9 47 31·79	31·71
48 2 23·13	29·21		51 55 20·76	21·32		10 20 45·93	45·82
107 52 40·43	46·62		52 18 56·95	57·30	57·25	6 33 42·42	42·22
87 6 38·11	44·28		52 17 19·22	19·65		7 34 53·97	53·77
85 42 42·87	48·99		52 12 24·17	24·74		9 49 45·53	45·37
357 29 30·87	36·92		51 41 11·55	12·13	10·06	9 47 32·02	31·96
48 2 23·72	29·80		51 55 20·41	21·02		10 20 46·15	46·05
			51 55 20·58	21·17	23·24	10 20 46·04	45·93

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BRANCH CHAIN OF GEODETIC LINES

Names of Three Successive Stations.	Angle of Azimuth from the First Station to the Third, as seen at the Second.	Log. Distance in Feet from Second Station to Third.
	° ′ ″	
Chingford, Wrotham, Dunstable	346 23 42·23	5·4369102
Wrotham, Leith Tower, White Horse Hill	227 37 39·89	5·4908363
Leith Tower, White Horse Hill, Dunstable	307 43 19·22	5·4089331
Wrotham, Leith Tower, Dunstable	280 38 41·86	5·4046570
Adopted for Dunstable		
Leith Tower, White Horse Hill, Arbury Hill	261 0 5·73	5·3984029
Leith Tower, Dunstable, Arbury Hill	139 44 30·86	5·3031466
Adopted for Arbury Hill		
Dunstable, Arbury Hill, Bardon Hill	221 38 52·41	5·2564050
Arbury Hill, Bardon Hill, Axe Edge	151 50 53·31	5·3700341
Bardon Hill, Axe Edge, Whittle Hill	193 0 47·20	5·2379457
Axe Edge, Whittle Hill, Rivington	99 50 39·46	4·7465243
Bardon Hill, Axe Edge, Rivington	176 15 5·60	5·2801115
Adopted for Rivington		
Axe Edge, Rivington, Delamere	54 41 28·85	5·1862213
Axe Edge, Whittle Hill, Delamere	53 14 20·28	5·2704922
Adopted for Delamere		
Rivington, Delamere, Everton	306 8 25·10	4·9871901
Axe Edge, Whittle Hill, Everton	84 5 42·53	5·2478109
Whittle Hill, Rivington, Everton	157 14 48·89	5·0940068
Adopted for Everton		
Rivington, Delamere, Heswell	280 19 54·73	4·9981098
Delamere, Everton, Heswell	80 14 18·25	4·6433041
Adopted for Heswell		
Rivington, Delamere, Edge Hill	304 57 24·84	4·9531907
Axe Edge, Rivington, Edge Hill	90 28 21·25	5·0998580
Adopted for Edge Hill		
Delamere, Edge Hill, Little Britain	158 35 45·75	4·3560974
Delamere, Heswell, Little Britain	263 2 39·61	4·5907585

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FROM WROTHAM AND LEITH TOWER TO LIVERPOOL OBSERVATORY.

Computed Azimuth of Second Station from North Meridian, as seen at the Third Station. 1st Method.	2nd Method.	Asimuth Observed.	Computed Latitude of Third Station. 1st Method.	2nd Method.	Latitude Observed.	Computed West Longitude from Greenwich of Third Station. 1st Method.	2nd Method.
° ′ ″	″	″	° ′ ″	″	″	° ′ ″	″
186 37 11·60	11·60	11·29	51 51 49·57	49·57		0 32 5·30	5·30
117 35 54·41	59·10	56·69	51 34 29·81	29·88		1 33 57·04	56·99
246 7 47·30	52·03	48·55	51 51 49·54	49·57		0 32 5·33	5·25
171 25 15·27	19·99	18·42	51 51 49·54	49·56		0 32 5·35	5·26
			51 51 49·55	49·56		0 32 5·33	5·26
198 52 48·93	53·69		52 13 27·27	27·32		1 12 35·14	35·01
130 37 52·04	54·99	51·57	52 13 27·28	27·31		1 12 35·14	35·04
			52 13 27·27	27·32	26·81	1 12 35·14	35·02
172 11 32·22	35·21	36·36	52 42 50·71	50·74		1 19 8·85	8·71
143 32 19·32	22·34	23·18	53 13 56·01	56·08		1 56 51·25	51·06
156 17 48·61	51·66	58·66	53 39 59·08	59·16		2 15 53·87	53·65
75 56 24·48	27·53		53 37 46·39	46·48		2 30 52·31	52·08
139 20 5·65	8·70		53 37 46·39	46·47		2 30 52·31	52·09
			53 37 46·39	46·47		2 30 52·31	52·08
13 53 24·23	27·24	35·21	53 13 17·16	17·25		2 41 3·71	3·52
29 11 56·05	59·06	66·35	53 13 17·15	17·25		2 41 3·73	3·55
			53 13 17·16	17·25	18·77	2 41 3·72	3·54
139 48 3·89	6·92		53 25 29·65	29·75		2 58 13·34	13·14
59 49 28·56	31·58		53 25 29·64	29·75		2 58 13·34	13·14
52 49 13·02	16·05		53 25 29·64	29·75		2 58 13·33	13·13
			53 25 29·64	29·75		2 58 13·34	13·14
113 53 20·44	23·46		53 19 57·35	57·42		3 5 59·42	59·23
39 56 6·50	9·51		53 19 57·35	57·46		3 5 59·44	59·25
			53 19 57·35	57·42		3 5 59·42	59·23
138 37 47·61	50·62		53 24 22·63	22·75		2 57 18·64	18·44
49 27 12·16	15·19		53 24 22·64	22·74		2 57 18·63	18·44
			53 24 22·63	22·75		2 57 18·64	18·44
117 9 5·68	8·69		53 26 4·91	5·05		3 2 51·99	51·78
196 58 30·49	33·51		53 26 4·93	5·00		3 2 51·99	51·81

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BRANCH CHAIN OF GEODETIC LINES

Names of Three Successive Stations.	Angle of Azimuth from the First Station to the Third, as seen at the Second.	Log. Distance in Feet from Second Station to Third.
	° ′ ″	
Delamere, Everton, Little Britain	142 12 0·14	4·2369016
Adopted for Little Britain		
Edge Hill, Little Britain, Liverpool Observatory (Transit)	11 6 33·95	4·1093730

BRANCH CHAIN OF GEODETIC LINES

Precelly, Kippure, Howth	257 1 57·96	4·9617237
Kippure, Howth, Dublin Observatory	56 4 4·66	4·7709985
Precelly, Kippure, Dublin Observatory	217 9 28·86	4·8829868
Adopted for Dublin Observatory		
Kippure, Howth, Poolbeg Lighthouse	18 33 19·96	4·3270654
Kippure, Dublin Observatory, Poolbeg Lighthouse	292 59 21·11	4·6445682
Adopted for Poolbeg Lighthouse		
Kippure, Howth, Kingstown Observatory	345 55 38·63	4·5117780
Howth, Poolbeg, Kingstown Observatory	109 16 40·45	4·2685985
Adopted for Kingstown Observatory		

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FROM WROTHAM AND LEITH TOWER TO LIVERPOOL OBSERVATORY.

Computed Azimuth of Second Station from North Meridian, as seen at the Third Station. 1st Method.	2nd Method.	Azimuth Observed.	Computed Latitude of Third Station. 1st Method.	2nd Method.	Latitude Observed.	Computed West Longitude from Greenwich of Third Station. 1st Method.	2nd Method.
° ′ ″	″	″	° ′ ″	″	″	° ′ ″	″
101 56 18·66	21·68		53 26 4·92	5·03		3 2 52·02	51·82
			53 26 4·92	5·03		3 2 52·00	51·80
308 17 53·69	56·70		53 24 46·34	46·45		3 0 5·30	5·11

FROM KIPPURE TO KINGSTOWN OBSERVATORY.

219 0 43·43	49·74		53 22 23·51	23·85		6 4 6·92	6·52
94 51 49·86		53·57	53 23 13·95			6 20 16·54	
178 55 17·21		17·05	53 23 13·96			6 20 16·54	
			53 23 13·96		12·83	6 20 16·54	
57 30 6·44	12·75		53 20 31·10	31·45		6 9 2·23	1·83
292 3 39·42			53 20 31·11			6 9 2·23	
			53 20 31·10	31·45		6 9 2·23	1·83
24 53 21·21	27·50		53 17 32·95	33·28		6 7 52·39	52·01
346 47 42·89	49·21		53 17 32·92	33·28		6 7 52·37	51·98
			53 17 32·94	33·28		6 7 52·38	52·00

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Two sets of numbers in these tables enable us to form a judgment of the general accuracy of the geodetic process. One is the series of observed azimuths, as compared with the computed azimuths; the other is the series of observed latitudes as compared with the computed latitudes.

That the observed azimuths indicate no serious error is evident from this circumstance: that they agree equally well, or nearly so, with the two sets as deduced by the first and by the second method, and that the discordances in every case are not greater than may be attributed to errors of observation of azimuth of the pole-star with an instrument not permanently fixed.

The observed latitudes agree very closely indeed with the computed latitudes in every instance, except Dunnose. But in the month of April, 1846, the new Ordnance Zenith Sector has been planted on a station (Week Down), very near to the Dunnose station, and very well connected with the great triangulation, and (as I am informed by Colonel Colby) the results already obtained leave no doubt that, from some cause or other, the latitude of Dunnose (observed with the old or Ramsden's Ordnance Zenith Sector) is discordant with that of Week Down (now observed with the new Sector) to the amount of about $3''\cdot2$, and that the observed latitude of Week Down agrees perfectly well with that computed geodetically.

I am, therefore, entitled to assert that there is no error in the fundamental azimuths, or in the geodetic observations or calculations, which can affect the accuracy of the computed longitudes of the chronometer stations.

Taking then the mean of the longitudes computed by the first and second method, and converting it into time, we have

	m	s
Geodetic arc of longitude from Greenwich to Liverpool	12	0·35
Chronometrical arc	12	0·05
Chronometrical arc, *smaller*		0·30

	m	s
Geodetic arc of longitude from Greenwich to Kingstown	24	31·48
Chronometrical arc	24	31·20
Chronometrical arc, *smaller*		0·28

	m	s
Geodetic arc of longitude from Greenwich to Feagh Main	41	23·07
Chronometrical arc	41	23·23
Chronometrical arc, *larger*		0·16

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And, if we divide the arc from Liverpool to Feagh Main into its sections,

	m	s
Geodetic arc of longitude from Liverpool to Kingstown	12	31·13
Chronometrical arc	12	31·15
Chronometrical arc, *larger*		0·02

	m	s
Geodetic arc of longitude from Kingstown to Feagh Main	16	51·59
Chronometrical arc	16	52·03
Chronometrical arc, *larger*		0·44

It appears, therefore, that the verticals at Greenwich and Liverpool are less inclined to each other, or that the earth's surface in England is flatter, than accords with the geodetic calculation; that the inclination of the verticals at Liverpool and Kingstown is, sensibly, precisely the same as that given by the geodetic calculation; and that the inclination of those at Kingstown and Feagh Main is greater than is given by the geodetic calculation, or that the earth's surface in Ireland is more curved than the elements of the geodetic calculation imply. But that, upon the whole arc, the difference of the chronometrical and geodetic results is very small.

I think that we are entitled to conclude that no improvement can be made in the assumed elements for the earth's figure, so far as they apply to the circumference of a parallel or to the measure of 1″ on the arc perpendicular to the meridian, which is the secondary element whose accuracy is tested by the comparison of the chronometrical and the geodetic determinations. And we may, therefore, lay down as one of the most certain *data* for the determination of the earth's figure, that,

In latitude 51° 40′, the complement of the logarithm of the number of feet in 1″ for an arc perpendicular to the meridian is 7·9928932; or the length of 1″ in an arc perpendicular to the meridian in latitude 51° 40′ is 101·6499 feet.

G. B. AIRY.

Royal Observatory, Greenwich,
1846, *May* 4.

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ADDENDUM.

In computing the geodetic differences of longitude, it might have been more accurate to employ the mean of the latitudes of the two stations on any line as argument to be used in the table of page 280, for converting the measure in feet into seconds of arc, instead of the latitude of the first station. The correction is thus investigated. If the second latitude is greater than the first by m minutes of arc, the logarithm of the number of seconds is to be diminished by $\frac{m}{2} \times 0{\cdot}00000042$ nearly; and if n minutes of arc, be the increase of longitude, the correction to that longitude in minutes of arc, is $-mn \times \frac{0'{\cdot}00000021}{\text{modulus of logarithms}}$; or, in seconds of time, it is $-mn \times \frac{0^s{\cdot}00000084}{\text{modulus of logarithms}} = -mn \times 0^s{\cdot}0000019$. This applies to a single arc: for the whole series, the correction is $-0^s{\cdot}0000019 \times \Sigma(mn)$. The values of $\Sigma(mn)$ are: from Greenwich to Liverpool, +4017; from Greenwich to Kingstown, +9795; from Greenwich to Valentia, +3429; and the corresponding corrections are nearly $-0^s{\cdot}01$, $-0^s{\cdot}02$, $-0^s{\cdot}01$.

1846, *July* 4.

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V. *On the Double Stars δ Cygni and γ Leonis.* *By J. R. Hind, Esq. F.R.A.S.*

Read May 8, 1846.

1. *On the Double Star δ Cygni.* Σ 2579.

This star was measured by Sir W. Herschel in 1783, at which period the distance of the components was found to be $2''\frac{1}{2}$. In 1802 and 1804 Sir William could no longer see the companion, and the star was also single to Sir John Herschel and Sir J. South. In 1823 the star was again examined by the latter astronomer from his observatory at Passy, near Paris, but with a magnifying power of nearly 800 it was perfectly round. At the beginning of the following year Mr. Struve re-discovered the companion with the Dorpat refractor, very little less than 2″ distant from the large star, wherefore he conjectured that the small star had made a complete revolution round the larger one in less than forty years. Subsequent observations have proved that this explanation is inadmissible; and Mr. Struve observes that the light of the small star must be variable, or the perihelion passage must have taken place about the time of Sir W. Herschel's later examinations. I have recently computed two orbits for this star, but neither of the ellipses will explain the anomaly; and it would therefore appear extremely probable that the light of the companion is really variable. The object is not of easy measurement, owing chiefly to the great brilliancy of the larger star.

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First Ellipse for δ Cygni.

(T)	Perihelion passage	1868·10
(π)	Projected perihelion	254° 50′
(Ω)	Node	109·22
(λ)	Angle between π and Ω on the orbit	143° 54′
(i)	Inclination to plane of heavens	19° 20′
(e)	Excentricity 0·6523	= sin 40° 43′
(μ)	Mean annual motion	− 119″·73
(a)	Semi-axis major	1″·598

Period of revolution, 180·4 years.

The formulæ for the calculation of the angle of position (θ) and distance (ρ) are:—

$$E - [3{\cdot}35073] \sin E = [2{\cdot}07822] \cdot (1868{\cdot}10 - t)$$

$$\tan \tfrac{1}{2} E = [0{\cdot}33844] \cdot \tan \tfrac{1}{2} v$$

$$\tan (\theta - 109^\circ\ 22') = [9{\cdot}97478] \cdot \tan (v + 143^\circ\ 54')$$

$$\rho_{//} = [0{\cdot}08322] \cdot \frac{\sin E}{\sin v} \cdot \frac{\cos (v + 143^\circ\ 54')}{\cos (\theta - 109^\circ\ 22')}$$

The comparison of the elements with observation is as follows:—

		θ (c−o)	ρ (c−o)
		° ′	″
1783·72	Sir W. HERSCHEL	0 0	+0·071
1826·55	STRUVE	+2 2	+0·052
1830·27	STRUVE	+2 12	+0·124
1832·72	Sir J. HERSCHEL	+3 46	+0·293
1834·43	STRUVE	−1 21	+0·047
1836·52	STRUVE	−0 10	−0·121
1837·78	SMYTH	−0 48	+0·142
1839·66	DAWES	0 0	+0·078
1840·67	DAWES	+0 20	
1841·51	MÄDLER	−1 36	
1841·89	DAWES	+0 15	−0·166
1842·56	SMYTH	−2 11	−0·321

With respect to Mädler's epoch for 1841·51, it must be observed that the result is a mean of three nights' measures, giving respectively 30° 3′, 26° 32′, and 23° 18′. Mr. DAWES' epoch for 1841·89 is a mean of four nights' measures, beautifully accordant with each other, and no doubt deserving great confidence.

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As the differences between 1826 and 1833 appeared large, I made another attempt to determine the elements, and obtained an ellipse with ☊ and i considerably altered, the other elements remaining pretty nearly the same as in my first orbit.

Second Ellipse for δ Cygni.

Perihelion passage	1862·87
Projected perihelion	258° 55′
Node	24·54
Angle between π and ☊ on orbit	243° 24′
Inclination to plane of heavens	46·23
Excentricity	0·60667 sin 37° 21′
Mean annual motion	−120″·87
Semi-axis major	1″·811

Period of revolution, 178·7 years.

The formulæ for the calculation of θ and ρ are—

$$E - [3{\cdot}31922] \sin E = [2{\cdot}08232]\,(1862{\cdot}87 - t)$$

$$\tan \tfrac{1}{2} E = [0{\cdot}30560] \,.\, \tan \tfrac{1}{2} v$$

$$\tan (\theta - 24^\circ\ 54') = [9{\cdot}83880] \,.\, \tan (v + 243^\circ\ 24')$$

$$\rho_{''} = [0{\cdot}15814] \,.\, \frac{\sin E}{\sin v} \,.\, \frac{\cos (v + 243^\circ\ 24')}{\cos (\theta - 24^\circ\ 54')}$$

Comparing the above elements with the observations, I find the following errors :—

	θ (c−o)	ρ (c−o)
	° ′	″
1783·82	0 1	−0·216
1826·55	+0 27	+0·127
1830·27	+0 54	+0·207
1832·72	+2 40	+0·376
1834·43	−2 17	+0·130
1836·52	−0 46	−0·043
1837·78	−1 16	+0·212
1839·66	−0 14	+0·139
1840·67	+0 43	
1841·51	−2 12	
1841·89	+0 25	−0·123
1842·56	−2 38	−0·286

The calculations have been made agreeably to the method described by

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Sir JOHN HERSCHEL in the *Memoirs of the Astronomical Society.* Though I cannot presume to say that the elements I have computed are any thing like *exact,* still I hope they will not be uninteresting as giving a general idea of the form of the orbit.

2. *On the Double Star γ Leonis.* Σ 1424.

This star was measured by Sir W. HERSCHEL in 1782, when the angle of position = 83° 30′. In 1845·9 the angle had increased to 107° 30′, shewing a change of about 24° in 63 years. Though this arc is far too small to enable us to determine the elements with certainty, I venture to give the following approximate numbers, resulting from a projection of the observations. Perihelion passage, 1760·1; projected perihelion, 308°; node, 67°; inclination, 69°; excentricity, 0·87; period, 296 years.

Among those stars which appear to deserve attention on the score of motion, are ξ *Scorpii,* 12 *Lyncis,* ζ *Aquarii,* 36 *Andromedæ,* 85 *Persei,* η *Tauri,* Σ 460, Σ 520, Σ 1126, v^1 *Cancri,* σ^2 *Ursæ Majoris,* 157 *Lyncis,* Σ 1457, Σ 1757, Σ 1819, 49 *Serpentis,* 167 *Herculis* (Σ 2107), 210 *Herculis* (Σ 2120), ο *Draconis,* and Σ 2438. A few years' careful observation will probably enable us to deduce the elements of some of these stars. The first on the list (ξ *Scorpii*) will, I believe, be found to revolve in a very elongated ellipse, the projected perihelion point answering to 190° or 200°. If this idea be correct, the angular velocity will be on the increase, until the star becomes one of extreme closeness; but ten or fifteen years' further observation will throw more light on this subject.

J. R. HIND.

Mr. BISHOP'S OBSERVATORY,
Regent's Park, 1846, *May* 8.

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VI. *Suggestions for Improving the Manufacture of Glass for Optical Purposes.* *By J. Nasmyth, Esq.*

Read May 8, 1846.

In entering on the inquiry as to the best means of obtaining perfect glass for telescopic purposes, we are aided in some measure by the knowledge that it is possible to attain the object in question, inasmuch as we know that the thing has been accomplished, and that therefore what we seek to discover does not involve any physical impossibility.

This being the case, although the process hitherto has been kept a profound secret, and its results dealt out with a niggardly hand, whether on account of the practical difficulties attending the process as hitherto conducted, or from mercenary motives, it is clear that we have only to make a due investigation of the nature of the difficulties and causes of failure in order to overcome them.

It has been with this view that I have for a considerable length of time paid particular attention to the manufacture of crown and flint-glass; and so far as I am able to judge, I have arrived at a pretty clear knowledge of the nature and origin of the causes which have hitherto defeated the attempts made in this country to produce perfect glass for telescopic purposes of any considerable magnitude.

The circumstances which give rise to the difficulties in question may be classed under the following heads:—

1st. Defects arising from imperfect materials in the composition of the glass.

2d. Defects arising from improper treatment of the glass after its perfect composition and mixture have been attained.

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With respect to the first class of difficulties, very fortunately they are by no means of frequent occurrence, inasmuch as, with ordinary care and attention to the selection, proportions, mixture, and treatment of the materials, very perfect glass can be produced. It is to the treatment of our glass *after* it is completely melted and formed in the pot that we have to direct our chief attention, there being no difficulty in producing perfect glass so far as *composition* is concerned.

It is under the second head, as it seems to me, that the only *real* difficulty arises. Hitherto, so far as I am aware, in the attempts which have been made in this country to obtain disks of glass of perfect homogeneity throughout, after all due care has been taken to obtain a pot of glass of perfect mixture and composition, the quantity of glass required to form the disks, or plates, from which the object-glasses were to be wrought, was either removed from the pot by *pouring* out portions of its contents on a flat surface or into a suitable mould, or the required quantity was lifted out of the pot by means of a ladle, and poured out in like manner on a flat surface or into a mould.

Now, I conceive that it is through this mode of *removing the glass from the original melting-pot that all, or nearly all, the mischief arises.* The glass ought never to be touched, removed, or disturbed in the slightest degree, after it is once brought to a perfectly fluid state in the furnace.

With the utmost care in the mixture of a pot of glass, it is certain that some portions of its contents will, in however slight a degree, vary in density from others; and consequently, if we do not give to the particles every chance and facility of arranging themselves in perfect harmony of composition and according to their relative density, we shall in vain expect to obtain any portion of them possessed of perfect homogeneity.

It appears to me that the system of management by which we are most likely to obtain glass absolutely free from defect, is to place a large pot of the most perfectly composed glass in the furnace, and to subject it to the very highest degree of heat which it can stand, *for the purpose of rendering its contents as perfectly fluid* as possible; the object of this being to give the utmost facility to all the particles of the fluid glass to *rise up or descend* in the pot, so as to arrange themselves in strata of perfect homogeneity and uniformity of density. In order that this most important object may be fully accomplished, I should not only maintain the highest

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degree of fluidity by intense heat, but also maintain that high temperature with the utmost steadiness and equality for at least three days, so that ample time should be given for every particle of the glass to arrange itself in its proper stratum along with its companion atoms of perfectly equal density. In such a mode of treatment, it is natural to expect that a *slight* variation in density would be found in the top stratum of glass as compared with that at the bottom of the pot, but the variation of the successive parallel strata would be so gradual, that one would not vary from another in any appreciable degree. Our pot of glass being thus brought into a condition of perfect harmony among its particles, all we have now to do is *to let it alone*, and permit the furnace to die out gradually, taking care that no draught have access to it, or any *irregularity* take place in the decrease of temperature. The cooling might thus require the lapse of some twenty days, more or less, as the case may be.

When the pot is become cool and fit to handle, let the glass be removed and *cut* into parallel slices; that is to say, let it be sawn across in slices *parallel to its top surface* by the simple and ordinary means employed by marble cutters. The result would probably be a series of disks of absolutely perfect glass. On the importance of such a result to the progress of astronomical science I need not dwell: but I most earnestly hope that the mode of obtaining this inestimable material here proposed will ere long be put to the test of actual experiment, and I am confident the result will be such as to be in the highest degree important to the science and honour of our country.

JAMES NASMYTH.

Note (received April 13, 1847).—Since I had the honour to make the preceding communication to the Royal Astronomical Society, I have had an opportunity afforded me of making an experiment on a very considerable scale with crown glass, according to the system detailed above. The result has afforded, so far, the most complete and satisfactory confirmation of the expectations I had formed from the proposed mode of treatment; masses of the most splendid glass having been thus obtained, to all appearance perfectly free from striæ or other irregularity.

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VII. *Original Observations of the Comet in Coma Berenices, discovered on the Morning of October 19, 1846, at Mr. Bishop's Observatory.*

Read Nov. 13, 1846.

1. *Instrumental Comparisons with β Leonis.*

Comet.

Chronometer Time of Transit over Vertical Wire.	Hour Circle Reading.	Instrumental N. P. D.
h m s	h m s	° ′ ″
5 48 47·0	17 53 2·0	74 55 25
5 51 37·0	17 55 54·0	74 55 25
5 56 36·0	18 0 50·5	74 55 35
5 59 47·2	18 3 59·0	74 55 40
6 3 43·0	18 7 56·5	74 55 45
6 6 57·0	18 11 8·0	74 55 45
6 10 26·5	18 14 36·5	74 55 50

Correction for sidereal time = + 3^m $54^s·0$

β Leonis.

h m s	h m s	° ′ ″
6 13 15·2	18 36 0·0	74 30 30
6 15 3·5	18 37 50·5	74 30 30
6 16 51·5	18 39 36·0	74 30 45
6 18 46·8	18 41 32·0	74 30 50
6 20 20·0	18 43 4·0	74 30 35
6 21 46·5	18 44 31·0	.....

Correction for sidereal time = + 3^m $54^s·0$

Comet.

h m s	h m s	° ′ ″
6 47 26·5	18 51 53·0	74 57 25
6 50 55·0	18 55 18·5	74 57 25
6 53 9·5	18 57 34·0	74 57 25

Correction for sidereal time = + 4^m $18^s·6$

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2. *Observations with the Wire-Micrometer.*

The comparison star is of ninth magnitude, following the comet, and *south* of it.

	h	m	s	Diff. Dec.
Comet	6	34	1·0	′ 16·112
Star	6	34	39·5	
Comet	6	37	18·5	16·616
Star	6	37	57·5	
Comet	6	40	6·5	16·891
Star	6	40	43·5	
Comet	6	42	27·5	17·095
Star	6	43	5·3	

1 Revolution of micrometer screw = 15″·955
Correction to observed times = $+4^{m}\ 18^{s}\cdot6$
Diameter of comet 2′ or $2'\frac{1}{2}$

These observations would appear to indicate a *northerly* motion in declination, instead of a motion *southward*, as shewn by the instrumental comparisons. The latter, however, is undoubtedly correct, as the change in $1^{h}\ 15^{m}$ was perceptible to the eye, and the comet had sensibly *approached* a star (11·12 magnitude) to the *south* of it, and almost touching the nebulosity. The micrometric differences are very uncertain, owing to the excessive faintness of the comet when the field was illuminated sufficiently to shew the thick wires.

J. R. HIND.

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VIII. *On Luminous Rings round Shadows. By the Rev. Baden Powell, M.A. F.R.S. F.R.A.S., Savilian Professor of Geometry, Oxford.*

Read December 11, 1846.

(1.) The remarkable optical phenomena attending total solar eclipses, especially the formation of a luminous ring round the disks, are now so well established, that although in a few particulars the accounts of different observers and on different occasions present discrepancies, and the appearances are connected with some circumstances of an apparently anomalous and perplexing kind, yet philosophers have not hesitated to indulge in conjectures as to their cause. These speculations can hardly be said, as yet, to amount to more than very general illustrations. But some experimental facts certainly seem to bear a resemblance to the phenomena in question, and in the present uncertain state of the inquiry, any such facts may claim attention as may seem at all likely to contribute to its elucidation.

In submitting some such results to the notice of this Society, I beg expressly to disclaim any idea of offering them as a complete explanation, for which I am persuaded we have not as yet sufficient data. I am induced to bring them forward, because *one* experiment which I devised some time ago was considered by the late Mr. Baily as not unworthy of being laid before this Society, though communicated to him without any such intention;* while I subsequently learned from that distinguished man, that he had been himself unable to repeat it successfully. But having since shewn it to several friends, and among them to our present excellent President, it is at his recommendation that I venture to submit it to the Society, and to accompany it with a brief notice of other experiments of a kindred nature in which I have been engaged, together with a few memoranda of earlier results bearing on the subject.

* Royal Astronomical Society's *Monthly Notices*, vol. v. p. 264, March 10, 1843.

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(2.) We have no positive evidence as to *when* or *by whom* the luminous ring was *first* observed. Yet so striking an appearance could hardly escape notice. The passage from Plutarch cited by M. Arago, viz. that "the moon, in an eclipse of the sun, allows a portion of the sun's light to extend beyond her own edges, and thus total darkness is prevented,"*—does not, perhaps, necessarily imply the appearance of a *ring*. Probably we may regard as the earliest actually recorded instance that in the eclipse of 1567, which, owing to the ring, was mistaken by many for an annular eclipse; Kepler having afterwards proved by calculation that it was total: and, observing a luminous ring in the eclipse of 1598, explained the former appearance in the same way. The ring was observed at Naples in 1605;† and in 1706, 1715, and other later instances, we have the full and well-known records of the most eminent astronomers down to the present day, which establish the phenomenon beyond question as a regular part of the appearance of a *total* eclipse; as also a modification of it, in the form of an arch of light, in an *annular* or very large eclipse; so as to leave no doubt that it must be dependent on *some constant optical cause*.

The facts must be so familiar to the members of this Society, from the valuable collections of authorities made by Mr. Baily and others,‡ that it would be wholly superfluous in me to refer to them in detail; one or two points, however, it is necessary to dwell upon.

(3.) The well-known discrepancies between different observers on the same occasion, as well as between the accounts of different eclipses, as to the colour, breadth, and general character of the ring, are not inconsiderable.

In regard to *colour*, the ring appeared, in 1715, to Halley, and, in 1779, to D'Ulloa, slightly prismatic, the red being nearest the moon; in 1842, to Mr. Airy, light pink; in 1706, to Duillier; and, in 1842, to Mr. Baily and M. Roche, white.

The very different estimates of the *breadth* (varying from $\frac{1}{12}$ of the moon's diameter, assigned by Duillier in 1706, up to a whole diameter, by D'Ulloa, 1779) are immediately connected with the extent to which the

* *Comptes Rendus*, 1842, vol. i. p. 847. † *Phil. Trans.* vol. xl. p. 177.

‡ See Royal Astron. Society's *Memoirs*, vol. i. p. 144, and vol. x. 9 to 16, 37, &c.; as also Royal Astron. Society's *Monthly Notices*, vol. v. p. 207, and M. Arago's preliminary notice, *Comptes Rendus*, 1842, part i. p. 843; as also many reports of observations in the same volume, part. ii.

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rays are stated in some instances to have darted out, especially in certain directions more than others, which is allowed for in some of the estimates, and, in all, the outer margin is allowed to be quite undefined, from the gradual fading off of the rays; while, in some instances, the light is described as waving, flickering, or even rotatory,* and, in others, as steady and at rest.

But, upon the whole, these discrepancies do not appear to me greater than may be fairly allowed for from the diversity of conditions, whether of the *magnitude* of the several eclipses, although *total*, the state of the atmosphere at different places and times, and the peculiarities of vision, or other causes affecting the individual observers.

(4.) The question, also, whether the ring is *concentric* with the disk of the sun, as was supposed by Maraldi and Ferrer, or with that of the moon, as held by Halley and Louville, and supported by Arago and others,† is perhaps answered by rather asking, whether it can properly be said to be concentric with *either*, except during the precise period of the eclipse being central, since it has been noticed to increase in breadth at the parts corresponding to the nearest approach of the limbs?‡

The fact, also, of a certain degree of *light* being diffused over the *whole dark disk*, after the obscuration was complete, seems related to the formation of the ring.§

In the transit of *Venus*, 1769, light was also seen surrounding the part of the planet off the sun, both at immersion and emersion, but this was ascribed to her atmosphere.‖

(5.) The singular *protuberances*, which appear to have been seen only in the eclipse of 1842, and in that of 1733 by Vassenius, at Gottenburg, according to M. Schumacher,¶ do not seem to belong to the ring, as was remarked by Mr. Airy, but, apart from the various conjectures as to their origin, may be safely affirmed to be due to some cause distinct from the rest of the ring.

* See Arago, *ubi supra.*

† *L'Institut.* 1842, p. 299.

‡ See Vince, *Astro.* p. 229. 8vo. Also Royal Astron. Society's *Monthly Notices*, vol. v. p. 220; and M. Roche, *L'Institut.* 1842, p. 287.

§ See Royal Astron. Society's *Monthly Notices*, vol. v. p. 219; *ibid. Memoirs*, vol. x. p. 17; *L'Institut.* 1842, p. 300; and *Comptes Rendus*, 1842, p. 649.

‖ See Royal Astronomical Society's *Memoirs*, vol. x. p. 27.

¶ See *Comptes Rendus*, 1842, part ii. p. 752.

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It seems to me hardly conceivable that they can be purely optical phenomena, as suggested by M. Valz and M. Arago,* or solely occasioned by the moon's atmosphere, as supposed by others. Whether they are too prominently marked to allow of their being regarded as only *interruptions* in the light of the ring, occasioned by some local *obstacles* to its emission or reflexion at these points, such as solar spots, or even clouds in the solar atmosphere, occurring on or very near the edge of the sun's disk on the side away from us, or whether they may be real bodies projecting from the surface, are points for future observations to elucidate. At all events, it is hardly to be expected that any experimental imitations of the ring should be likely to exhibit any appearance of the kind.

As this is the object at present in contemplation, it would, for the same reason, be out of place here to refer to the equally remarkable phenomena of the *beads* and *threads*, the *wavings or distortions of the limb*, and other phenomena which are totally distinct from the ring, and which, though they appear with great probability to be at least partly due to optical causes, must, I think, be referred to a different class of optical phenomena, to which I hope to recur on a future occasion, and to illustrate both these and some other points affecting astronomical observations.

(6.) In the attempt to assign a *cause* for the luminous ring, astronomers have been also divided. Kepler speculated whether it was due to some kind of combustion round the sun, or to refraction of his rays by the moon's atmosphere.† In this last opinion many have agreed; others have more generally attributed it to some peculiar effect of the solar atmosphere; and some, especially Olbers, in a letter to Humboldt,‡ expressly attribute it to the zodiacal light, an opinion opposed by M. Roche.§ But De l'Isle,‖ and more lately Arago and Valz, regard it altogether as a phenomenon of diffraction, to which cause the latter philosophers without hesitation set down even the singular and anomalous appearances of the protuberances.¶

Several phenomena, indeed, somewhat of the same class, have been often vaguely ascribed to "diffraction," or "inflexion." But these terms have

* *L'Institut.* 1842, p. 308.

† See Arago's *Report.*

‡ *Cosmos*, note 69, p. 415; transl. See also Vince, p. 281. 8vo.

§ *L'Institut.* 1842, p. 287–300.

‖ Smyth's *Cycle*, vol. i. p. 472.

¶ *L'Institut.* 1842, p. 308.

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been employed in a very loose sense, and in some instances with a meaning quite remote from that usually conveyed, especially by the older writers; thus Hooke used the term "inflexion" as applied to atmospheric refraction.*

(7.) *Analogous facts* have been observed by M. Necker (in a letter to Sir D. Brewster),† who describes luminous rings surrounding objects seen in shadow against the sky when the sun was sunk behind the ridge of a mountain. This was confirmed by Mr. Fox Talbot,‡ who also noticed the same luminous margin with a telescope, when the peak of a mountain or other objects, as trees, &c. eclipsed the sun; and similarly when the *moon* was hidden by a building. He unhesitatingly ascribes the effect to diffraction.

Professor C. Piazzi Smyth has also mentioned to me that he has witnessed, at the Cape of Good Hope, the same appearance surrounding mosquitoes flying about on the edge of a cliff which just hid the sun from the spectator, in so remarkable a degree, that while the insects were themselves invisible, their position was marked by the bright light in which they were enveloped.

M. Quetelet,§ in referring to the observations of M. Necker, remarks that the effect is analogous to that of intercepting the sun by a cylindrical rod, when the light encroaches on each side; and if the rod be thin, the two portions of light overlap, and make the centre part the brightest. But it appears to me extremely doubtful whether these are really cases of the same kind as the former.

(8.) *Experimental imitations* of the luminous ring, by artificially eclipsing the sun, were long ago made by De l'Isle and La Hire;‖ and such an imitation is also spoken of by Mr. Baily.¶

Professor Chevallier** describes a more elaborate attempt to produce such an effect by means of a finely turned circular opaque disk, fixed in the focus of a telescope, and made to eclipse the sun. Prof. C. P. Smyth has also mentioned to me that occultations of stars by a similar disk are unattended by any other phenomena of the kind than what arises from the imperfection of the focus.

* *Microgr.* p. 220; and "Lectures on Astronomy," &c. *Miscellaneous Works*, p. 466.

† "Phil. Mag." Nov. 1832, and in the "Biblioth. Univ. Déc. 1832.

‡ "Phil. Mag." June 1833.

§ Notes to translation of Herschel "On Light," p. 558.

‖ "Mém. Acad. Paris," 1715, p. 166. ¶ R. Ast. Soc. *Monthly Notices*, vol. v. p. 212.

** Royal Ast. Soc. *Monthly Notices*, vol. v. p. 186.

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It appears to me, that the conditions of this case are such that no appearance like that of the ring *could* be produced, since the focal image itself is here, optically speaking, the origin of light; and it is essential to all phenomena analogous to those of diffraction, that the intercepting body should be at *some sensible distance* from the *origin* of light, whereas it is here *coincident* with it; and if it partly cover the image, this is only equivalent to limiting the size of the luminous body.

(9.) Among the experiments described by Newton, in the third book of the *Optics*, and so emphatically mentioned as unfinished, there is one which includes the account of an appearance which seems never to have been fully understood; and, under the conditions employed by Newton, would probably require extreme precaution to repeat it. As it appears to me to bear closely on the present subject, it may be desirable briefly to refer to it.

The sun's light being admitted through a hole $\frac{1}{4}$ of an inch in diameter, and partly intercepted by a knife-edge fixed along one side of a hole $\frac{1}{4}$ of an inch square in a screen, and falling on a paper beyond, Newton saw "two *streams of faint light* shoot out both ways from the beam of light into the shadow, like the tails of comets."* (That is, I presume, one from the knife-edge, the other from the opposite side of the hole.)

Again, placing his eye to receive the light, he saw "*a line of light upon the edge* (of the knife) all along it;" it was "contiguous to the edge, and narrower than the innermost fringe;" and "between the edge and the first fringe." That is, where the fringe *would have been* had it been formed; for afterwards (in Obs. 7), he remarks, that "in Obs. 5, the *fringes* did not appear; but, by reason of the breadth of the hole, became so broad as to run into one another, and make one continued light in the beginning of the streams." Newton then clearly distinguishes this peculiar phenomenon from the ordinary diffraction-fringes.

(10.) For all phenomena of *diffraction*, strictly so called, the essential conditions are, (1) that the origin of light be a point, or as nearly as possible so; (2) that the area of the rays diverging from it extend beyond the edge of the opaque diffracting body.

In these experiments, the best origin of light is the focal image of the sun (thrown into the proper direction by an inclined plane mirror) produced by a

* "Optics," book iii. part i. obs. 5.

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lens of very short focus. Yet the phenomena are still seen, though less distinctly, if simply a small hole be substituted. And on trying the experiment with a series of holes, varying in diameter from about $\frac{1}{40}$ to $\frac{1}{4}$ of an inch, I find the *diffraction* phenomena cease to be distinctly seen when the hole is greater than $\frac{1}{8}$ of an inch. These phenomena, also, can only be seen *directly* as forming an optical image in the air, which is magnified by a small eye-lens.

With apertures of any diameter up to $\frac{1}{4}$ of an inch or more, and whether the area of the rays reach beyond the edge of the opaque body, or lie even considerably within it, I find (using a small circular disk) that it is seen by the naked eye, or with a telescope at a distance, edged *by a bright luminous ring*, which cannot be seen with the eye-lens; and is, therefore, *not* an optical image, like the diffractive fringes, but is seen in the telescope distinctly when in focus for the opaque disk. This phenomenon, then, is *not* one of *diffraction*, at least in the strict sense of the term.

With a straight edge it is equally seen as a line of light running along it, and is evidently the same phenomenon as that observed by Newton above mentioned (9).

And again, when the origin is formed by a lens of short focus, the ring is seen as before, but less perfectly; while the diffraction fringes are seen perfectly with the eye-lens. If, for the origin, a lens of somewhat longer focus be used, the ring is better seen, but the fringes less distinctly.

(11.) The origin being a hole, the area of the rays, of course, varies, as either the size of the hole or the distance is varied; and the ring continues to be formed when the area of the rays, being concentric with the disk, owing to either cause, is made to occupy spaces successively decreasing from the diameter of the disc to about $\frac{1}{4}$ of it; beyond which limit the ring ceases to be distinguishable. It is somewhat broader in proportion as the area of the rays approaches that of the disc; and if *not* concentric, it increases in breadth at that point where the approach is nearest. Changes in the distance of the eye from the disk produce very little, if any, change in the breadth of the ring.

(12.) The ring was examined by a telescope with a power of 20, having cross-wires at its focus; the intersection of the wires was fixed accurately on the edge of the disk before the light was admitted, and on its admission, the ring extended sensibly beyond. Again it was fixed on the exterior edge of

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the ring, and shutting out the light, the edge of the disk fell within. A screen was placed near the disk, so as to intercept half the shadow: the half ring round the exposed part was seen to project at its two terminations beyond the outline of the dark disk.

Some little degree of light appears to extend within the dark part faintly, of a bluish tint; that of the ring is yellowish.

(13.) To determine the possible influence of reflexion from the edge, the experiment was repeated with the disk smoked by a candle, and again with a metallic button having a perfectly smooth and brightly polished edge; but the results were unaltered.

The aperture of the telescope was diminished to about $\frac{1}{4}$ of an inch. The ring was equally clear, though the diffraction-fringes arising from the contraction of the aperture were seen also.

Every little irregularity in the edge appears drawn out, as it were, into minute luminous threads, which seem to form a part of the ring, and to depend on the same cause. These might be imagined to resemble the well-known beads in an eclipse, but I conceive their nature to be different.

(14.) When the origin is a hole (and not the focus of the lens), the disk being *within* the area of the rays, if the shadow of the disk be examined by an eye-lens of two inches' focus, there appear, at all parts of the circumference, *streaks* of yellowish light, *radiating into the shadow;* and crossing at the centre, they form there a round bright spot. With a straight edge the same streaks are seen projecting perpendicularly from the edge into the shadow. They fade off gradually, so that it is difficult to determine their extent. The appearance of separate streaks is clearly due to irregularities in the edge; for, with a finely polished edge, there is only a diffused light over the disk, forming a well-defined, bright, round spot at the centre.

This, then, appears to be precisely the other part of the phenomenon observed by Newton, as before described (9).

(15.) When a *straight* edge is used, the line of light continues to be seen along it, while the eye is depressed through a considerable space; but it is impossible to define precisely the angular extent, from the gradual shading off of the light.

It is evident that the same light, which appears to the eye thus condensed into a line on the edge, causes the appearance of the streaks perpendicular to the edge, which are seen by the eye-lens at some distance; but which I have

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not succeeded in throwing on a screen after the manner of Newton, though possibly only from want of sufficient darkness in the room.

When the disk is used, it is equally evident that the light forming the ring consists of rays, which converge to successive centres at successive distances from the disk, and are thus seen by the eye-lens.

(16.) A modification of the same phenomenon is observed in the case which I described to the British Association at the Southampton Meeting, 1846. The image of the sun reflected from a small globule of mercury forms the origin of light; and on being intercepted by the opaque disk, so that the ray falls quite within the edge of the disk, at the distance of about two inches, so that both the point of light and the disk are in focus together in a small telescope at 10 or 12 feet distance, a spot of light appears on the edge of the disk at the part nearest to the rays, and the light appears also to project a little way into the dark part, the rays approaching and crossing like the cusp of a caustic.

This effect might be supposed to have some analogy with the much-disputed appearance of the projection of a star on the moon in an occultation, were it not that in this last case the data seem too uncertain and too obviously dependent, at least in a great degree, on some peculiar and unknown circumstances affecting the observer, to allow us as yet to regard the subject as in a fit condition for investigating its cause. That phenomenon has been, however, often vaguely set down to *diffraction*, with which, in the restricted sense of the term, it is thus manifestly unconnected; though, in a wider sense, such an effect may be due to causes of the same class.

(17.) The preceding experiments were all made by means of the *sun's light*. There are well-known difficulties in performing any diffraction-experiments by *candle light*. But, as in the principal diffraction-experiment, I long ago succeeded in devising a method of exhibiting it by the light of a flame,* so the phenomenon of the ring may be beautifully seen on forming an extended luminous image by means of a lens of about two inches' focus, limited by a circular aperture in a screen, and having the flame at its focus. On placing a circular disk, of rather larger diameter than the aperture, about one foot in front of it, and causing it totally and centrally to eclipse the

* *Phil. Mag.* Jan. 1832, p. 3.

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luminous disk, it will be seen surrounded by a brilliant luminous ring, the eye being at a few feet distance.*

Mr. Airy, in his observations on the eclipse of 1842, incidentally suggests such an imitation as occasionally witnessed in an eclipse of a street lamp.†

When the shadow is thrown on a white screen, at about one foot distant from the disk, the middle of the shadow appears faintly illuminated; but I could detect no *streaks*, as in the case of the solar light; nor is the faint illumination perceptible to the eye viewing the disk directly. The image of the ring on the screen is broad, faint, and extremely ill-defined.

(18.) To account for a portion of light being brought into existence outside the edge of an intercepting body, and altogether beyond the area of the rays, a theoretical suggestion has been made by M. Babinet, the main principle of which appears to me satisfactory, though it may be, perhaps, difficult at present to pursue it into details. This principle is simply, that on the undulatory theory, at points exterior to the area of the rays, there is no light, owing to the mutual destruction of the secondary waves. If, then, of the two rays proceeding to any such point to destroy each other, we intercept *one* by an *obstacle*, the *other* remains, and gives rise to a point of light at that point, *i.e.* just beyond the obstacle. A series of luminous points thus created by the removal of interfering rays, will give rise to the luminous border upon the edge.‡

Without pretending to say that this explanation is perfectly satisfactory, I will merely add, that the phenomenon appears to me anomalous, unless it can be referred to some such principle; but imperfect as the whole investigation confessedly is, it is by thus making the facts known that we may most reasonably hope to elicit some better elucidation of them.

* This is the experiment alluded to in the Royal Ast. Soc. *Monthly Notices*, vol. v. p. 264.

† Royal Ast. Soc. *Monthly Notices*, vol. v. p. 219.

‡ *Nouv. Bulletin des Sciences*, Nov. 1832. Quetelet, Appendix to translation of Herschel's Treatise *On Light*.

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IX. *Double Stars observed at Poonah in* 1845–6. *By W. S. Jacob, Captain, Bombay Engineers.*

Read November 13, 1846.

[Note.—*The following observations were made with a telescope by Dollond, five feet in focal length, mounted on an equatoreal stand. The abbreviation "Cyc." in the second column denotes Smyth's "Cycle of Celestial Objects."*]

Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
1	38 Piscium ...	0 09	82 00	238·1	12	4	87	....	..	..	..	$7\frac{1}{2}$–8	1845·90
1,	.....	....	....	238·04	16	5	152	4·84	10	4	152	....	1846·40
2	η Cassiopeiæ	0 39·8	33 00	97·2	15	5	87	8·85	14	6	87	$3\frac{1}{2}$–8	1845·86
2,	.....	....	....	100·5	11	5	152	8·89	12	4	152	....	1846·41
3	ζ Phœnicis ..	1 01·8	146 05	241·8	15	5	87	5·53	8	4	87	5–10	1845·87
3,	.....	....	....	241·7	13	5	87	....	..	..	..	....	1845·88
3,,	.....	....	....	241·6	10	4	87	....	..	..	..	....	1845·90
4[a]	Cyc. 60 A B	1 28·0	83 09	25·0	6	4	240	1·5	*	..	..	7–8	1845·81
4,[a]	.....	....	....	21·9	10	5	152	1·6	*	..	..	$7\frac{1}{2}$–$7\frac{1}{2}$	1845·91
4,[c]	.... A C	....	....	69·3	6	3	152	74·44	2	2	152	$7\frac{1}{2}$–$11\frac{1}{2}$	1845·91
5	.....	1 28·7	120 47	84·3	12	4	152	3·	*	..	..	7–8	1845·81
5,	.....	....	....	80·9	18	6	152	2·76	8	4	152	....	1845·91
6	.....	1 33·2	147 00	186·2	15	5	87	4·16	8	4	87	$6\frac{1}{2}$–$6\frac{1}{2}$	1845·87
6,	.....	....	....	185·8	15	5	87	....	..	..	..	....	1845·88
7	α Piscium ...	1 54·0	88 00	333·0	9	3	152	4·04	4	2	152	5–6	1842·94
7,	.....	....	....	329·9	22	7	240	4·02	12	4	240	5–6	1845·81
7,,	.....	....	....	330·3	12	4	87	4·37	15	8	87	....	1845·85
7,,,	.....	....	....	330·6	14	4	87	....	..	..	..	....	1845·90
8	.....	2 37·2	131 10	45·8	11	5	152	1·3	*	..	..	$7\frac{1}{2}$–$8\frac{1}{2}$	1845·81
8,	.....	....	....	46·1	12	5	152	....	..	..	..	....	1845·81

3. A, yellow.
3,. B, blue.
6. A, yellow.
6,. B, blueish.
* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
9	θ Eridani...	2 52·4	130 50	82·1	15	5	87	8·60	18	6	87	3–3½	1845·86
9,	.....	....	....	80·5	14	5	152	8·76	12	6	152	2½–3½	1845·86
10	.....	3 11·8	109 07	109·1	12	4	152	5·73	8	4	152	7½–9½	1845·81
10,	.....	....	....	109·3	14	4	152	....	..	..	..	....	1845·89
10,,	.....	....	....	110·5	11	4	152	....	..	..	..	....	1845·91
11	426 A. S. C. ..	3 42·8	128 05	200·0	16	5	87	7·28	6	4	87	5–5½	1845·86
11,	.....	....	....	199·8	19	5	152	7·07	6	4	152	....	1845·87
12	39 Eridani...	4 0·71	100 39	151·2	8	4	152	7·29	2	2	152	5–9½	1845·81
12,	.....	....	....	149·0	11	5	87	....	..	..	..	....	1845·81
12,,	.....	....	....	147·8	13	5	87	5·50	7	4	87	....	1846·10
12,,,	.....	....	....	149·9	14	5	87	6·22	11	4	87	....	1846·11
13	Fol. 41 Eridani	4 13·4	124 17	160·2	12	4	152	6·14	8	4	152	7–9½	1845·81
13,	.....	....	....	158·2	9	4	87	....	..	..	..	....	1845·86
13,,	.....	....	....	160·8	10	5	152	5·56	6	4	152	8½–10½	1845·87
14	2 Camelopardi	4 27·8	36 50	307·4	10	4	152	1·8	*	..	..	6–8	1845·84
14,	.....	....	....	305·5	12	5							
15	Σ 670....	4 28	100 06	259·1	16	5	87	12·85	8	4	87	7½–9½	1846·11
15,	.....	....	....	259·3	25	5	87	12·89	11	4	87	7–7½	1846·22
16	55 Eridani...	4 36	99 06	316·4	9	5	87	....	..	..	..	7–7	1846·11
16,	.....	....	....	317·3	20	4	87	9·50	14	4	87	....	1846·22
16,,	.....	....	....	317·3	21	6	87	9·69	21	6	87	....	1846·23
17	Cyc. 176..	4 50	88 35	177·1	8	3	152	2·5	*	..	..	8–9	1845·81
17,	.....	....	....	177·0	10	4	87	2·3	*	..	..	8½–8½	1845·91
18	ϱ′ Orionis...	5 05	87 20	60·8	13	5	87	7·19	10	4	87	5–9½	1846·12
18,	.....	....	....	60·3	20	6	87	6·87	10	4	87	5½–10	1846·29
19	Prec. τ Orionis	5 07·3	97 11	311·7	5	2	152	3·75	4	2	152	7–9½	1845·78
19,	.....	....	....	312·1	15	4	152	4·74	8	4	152	....	1845·80
20	26 Aurigæ...	5 29	59 36	266·8	21	7	87	11·97	9	4	87	6–8½	1846·19
20,	.....	....	....	266·3	23	6	87	12·09	18	6	87	....	1846·20
21[a]	ϵ Orionis A*a*	5 31	92 42	234·3	6	3	152	10·55	2	2	152	4–11	1845·78
21,[a]	.....	....	....	236·2	4	2	152	....	..	..	..	....	1845·84
21[b]	.....BC	....	....	231·0	2	1	152	....	..	..	..	8–7	1845·78
21,[c]	.....AC	....	....	60·7	9	3	152	....	..	..	..	....	1845·84

11. A, greenish yellow. 11,. B, reddish.

16. This position was registered 326·4, weight 18; I have assumed an error of 10°, but given only half the weight.

19,. Very heavy dew, which could not entirely be kept off by the cap. * Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
21[a]	σ Orionis AB	....	....	84·1	12	4	152	....	..	..	..	....	1845·84
22	ζ Orionis	5 33	92 02	156·0	6	3	152	2·59	12	4	152	2–5	1845·74
22,	.....	....	....	153·9	10	5	152	....	..	..	..	....	1845·81
22„	.....	....	....	154·6	13	5	152	....	..	..	..	....	1845·84
23	Cyc. 228..	5 40	58 16	63·6	19	6	87	3·93	8	4	87	7½–8	1846·20
23,	.....	....	....	61·0	10	4	87	....	..	..	..	....	1846·23
24	.....	6 02·4	104 35	185·2	9	5	152	1·8	*	..	..	7–9½	1845·80
25	.....	6 14	119 34	206·2	17	5	87	12·82	11	4	87	9–10	1846·21
25,	.....	....	....	205·3	17	5	87	12·76	11	4	87	....	1846·22
25„	.....	....	....	207·0	14	5	152	12·80	4	2	152	9–10½	1846·29
26	8 Monocerotis	6 15	85 20	26·1	15	4	87	14·21	8	4	87	5–8	1846·12
26,	.....	....	....	25·3	13	5	120	13·35	6	2	120	6–8½	1846·17
27[b]	.....BC	6 19·8	125 01	315·2	11	4	87	4·12	2	2	87	8–8½	1846·12
27,[b]	.....	....	....	317·1	13	5	87	3·67	8	4	87	8½–9	1846·22
27[a]	.....AB	....	....	48·9	10	3	87	95·8	1	1	87	7–8½	1846·22
28[a]	11 Monocerotis	6 21	96 56	132·1	11	4	152	6·49	4	2	152	6–7	1846·16
28,[a]	.....AB	....	....	132·5	17	5	120	7·44	13	4	120	....	1846·17
28[b]	.....BC	....	....	102·8	14	4	152	2·7	*	..	..	7–7	1846·16
28,[b]	.....	....	....	103·1	17	5	120	3·14	8	4	120	....	1846·17
29	38 Geminorum	6 46	76 38	169·3	16	5	87	6·18	16	4	87	6–9	1846·24
29,	.....	....	....	170·1	21	6	87	6·25	19	4	87	6–8½	1846·29
30	μ Canis Maj.	6 48·8	103 51	338·8	9	3	152	3·	*	..	..	....	1845·80
30,	.....	....	....	338·8	8	6	152	....	..	..	..	5½–9½	1845·82
30„	.....	....	....	337·7	19	5	152	2·97	8	4	152	....	1846·29
31	ϑ Geminorum	7 11	67 41	201·3	13	5	120	7·74	10	4	120	3–9	1846·31
31,	.....	....	....	199·4	21	5	87	7·70	10	4	87	....	1846·32
32	π Argûs	7 11·7	126 54	212·5	10	2	87	65·	*	..	..	3–9	1846·22
32,	.....	....	....	212·1	17	5	87	68·48	8	4	87	3–9½	1846·25
33[a]	.....AB	7 11·9	126 28	277·0	12	2	87	238·73	2	1	87	5½–5½	1846·21
33,[a]	.....	....	....	276·98	11	2	87	....	..	..	..	....	1846·22
33[c]	.....AC	....	....	215·2	9	2	87	116·85	1	1	87	5½–10	1846·21
33,[c]	.....	....	....	215·0	11	3	87	....	..	..	..	....	1846·22
33[d]	.....CD	....	....	210·8	13	5	87	3·	*	..	..	10–10	1846·21

24. Difficult from closeness and inequality. N.B. I have looked for this star several times since, without seeing it double.
29. The suspicion of rotation seems confirmed.
30,. Definition very bad.
31. The motion of this star seems confirmed.
* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
9	θ Eridani...	2 52·4	130 50	82·1	15	5	87	8·60	18	6	87	3–3½	1845·86
9,	.....	....	....	80·5	14	5	152	8·76	12	6	152	2½–3½	1845·86
10	.....	3 11·8	109 07	109·1	12	4	152	5·73	8	4	152	7½–9½	1845·81
10,	.....	....	....	109·3	14	4	152	....	..	..	..	....	1845·89
10,,	.....	....	....	110·5	11	4	152	....	..	..	..	....	1845·91
11	426 A. S. C. ..	3 42·8	128 05	200·0	16	5	87	7·28	6	4	87	5–5½	1845·86
11,	.....	....	....	199·8	19	5	152	7·07	6	4	152	....	1845·87
12	39 Eridani...	4 0·71	100 39	151·2	8	4	152	7·29	2	2	152	5–9½	1845·81
12,	.....	....	....	149·0	11	5	87	....	..	..	..	....	1845·81
12,,	.....	....	....	147·8	13	5	87	5·50	7	4	87	....	1846·10
12,,,	.....	....	....	149·9	14	5	87	6·22	11	4	87	....	1846·11
13	Fol. 41 Eridani	4 13·4	124 17	160·2	12	4	152	6·14	8	4	152	7–9½	1845·81
13,	.....	....	....	158·2	9	4	87	....	..	..	..	....	1845·86
13,,	.....	....	....	160·8	10	5	152	5·56	6	4	152	8½–10½	1845·87
14	2 Camelopardi	4 27·8	36 50	307·4	10	4	152	1·8	*	..	..	6–8	1845·84
14,	.....	....	....	305·5	12	5							
15	Σ 670	4 28	100 06	259·1	16	5	87	12·85	8	4	87	7½–9½	1846·11
15,	.....	....	....	259·3	25	5	87	12·89	11	4	87	7–7½	1846·22
16	55 Eridani...	4 36	99 06	316·4	9	5	87	....	..	..	..	7–7	1846·11
16,	.....	....	....	317·3	20	4	87	9·50	14	4	87	....	1846·22
16,,	.....	....	....	317·3	21	6	87	9·69	21	6	87	....	1846·23
17	Cyc. 176..	4 50	88 35	177·1	8	3	152	2·5	*	..	..	8–9	1845·81
17,	.....	....	....	177·0	10	4	87	2·3	*	..	..	8½–8½	1845·91
18	ε′ Orionis...	5 05	87 20	60·8	13	5	87	7·19	10	4	87	5–9½	1846·12
18,	.....	....	....	60·3	20	6	87	6·87	10	4	87	5½–10	1846·29
19	Prec. τ Orionis	5 07·3	97 11	311·7	5	2	152	3·75	4	2	152	7–9½	1845·78
19,	.....	....	....	312·1	15	4	152	4·74	8	4	152	....	1845·80
20	26 Aurigæ...	5 29	59 36	266·8	21	7	87	11·97	9	4	87	6–8½	1846·19
20,	.....	....	....	266·3	23	6	87	12·09	18	6	87	....	1846·20
21[a]	ε Orionis A*a*	5 31	92 42	234·3	6	3	152	10·55	2	2	152	4–11	1845·78
21,[a]	.....	....	....	236·2	4	2	152	....	..	..	..	....	1845·84
21[b]	.....BC	....	....	231·0	2	1	152	....	..	..	..	8–7	1845·78
21,[c]	.....AC	....	....	60·7	9	3	152	....	..	..	..	....	1845·84

11. A, greenish yellow. 11,. B, reddish.

16. This position was registered 326·4, weight 18; I have assumed an error of 10°, but given only half the weight.

19,. Very heavy dew, which could not entirely be kept off by the cap. * Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
21[A]	ε Orionis AB	....	....	84·1	12	4	152	....	..	..	..	....	1845·84
22	ζ Orionis	5 33	92 02	156·0	6	3	152	2·59	12	4	152	2–5	1845·74
22,	.....	....	....	153·9	10	5	152	....	..	..	..	....	1845·81
22„	.....	....	....	154·6	13	5	152	....	..	..	..	....	1845·84
23	Cyc. 228..	5 40	58 16	63·6	19	6	87	3·93	8	4	87	7½–8	1846·20
23,	.....	....	....	61·0	10	4	87	....	..	..	..	....	1846·23
24	.....	6 02·4	104 35	185·2	9	5	152	1·8	*	..	..	7–9½	1845·80
25	.....	6 14	119 34	206·2	17	5	87	12·82	11	4	87	9–10	1846·21
25,	.....	....	....	205·3	17	5	87	12·76	11	4	87	....	1846·22
25„	.....	....	....	207·0	14	5	152	12·80	4	2	152	9–10½	1846·29
26	8 Monocerotis	6 15	85 20	26·1	15	4	87	14·21	8	4	87	5–8	1846·12
26,	.....	....	....	25·3	13	5	120	13·35	6	2	120	6–8½	1846·17
27[b]	..... BC	6 19·8	125 01	315·2	11	4	87	4·12	2	2	87	8–8½	1846·12
27,[b]	.....	....	....	317·1	13	5	87	3·67	8	4	87	8½–9	1846·22
27[c]	..... AB	....	....	48·9	10	3	87	95·8	1	1	87	7–8½	1846·22
28[c]	11 Monocerotis	6 21	96 56	132·1	11	4	152	6·49	4	2	152	6–7	1846·16
28,[c]	..... AB	....	....	132·5	17	5	120	7·44	13	4	120	....	1846·17
28[b]	..... BC	....	....	102·8	14	4	152	2·7	*	..	..	7–7	1846·16
28,[b]	.....	....	....	103·1	17	5	120	3·14	8	4	120	....	1846·17
29	38 Geminorum	6 46	76 38	169·3	16	5	87	6·18	16	4	87	6–9	1846·24
29,	.....	....	....	170·1	21	6	87	6·25	19	4	87	6–8½	1846·29
30	μ Canis Maj.	6 48·8	103 51	338·8	9	3	152	3·	*	..	..	....	1845·80
30,	.....	....	....	338·8	8	6	152	....	..	..	..	5½–9½	1845·82
30„	.....	....	....	337·7	19	5	152	2·97	8	4	152	....	1846·29
31	ϑ Geminorum	7 11	67 41	201·3	13	5	120	7·74	10	4	120	3–9	1846·31
31,	.....	....	....	199·4	21	5	87	7·70	10	4	87	....	1846·32
32	π Argûs	7 11·7	126 54	212·5	10	2	87	65·	*	..	..	3–9	1846·22
32,	.....	....	....	212·1	17	5	87	68·48	8	4	87	3–9½	1846·25
33[e]	..... AB	7 11·9	126 28	277·0	12	2	87	238·73	2	1	87	5½–5½	1846·21
33,[e]	.....	....	....	276·98	11	2	87	....	..	..	..	....	1846·22
33[e]	..... AC	....	....	215·2	9	2	87	116·85	1	1	87	5½–10	1846·21
33,[c]	.....	....	....	215·0	11	3	87	....	..	..	..	....	1846·22
33[d]	..... CD	....	....	210·8	13	5	87	3·	*	..	..	10–10	1846·21

24. Difficult from closeness and inequality. N.B. I have looked for this star several times since, without seeing it double.
29. The suspicion of rotation seems confirmed.
30,. Definition very bad.
31. The motion of this star seems confirmed.
* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
33,[d]	π Argûs CD	....	....	212·2	9	4	87	....	..	..	..	....	1846·22
34	Castor ...	7 25	57 47	251·3	15	6	152	5·04	24	6	152	2–2½	1845·78
34,	.....	....	....	250·4	15	3	152	4·90	32	8	152	....	1845·80
34,,	.....	....	....	250·3	23	5	152	4·92	14	4	152	....	1846·32
35	Cyc. 294..	7 27·8	113 08	286·7	24	5	87	9·46	14	4	87	6–6	1846·25
35,	A.S.C. 935–6	....	....	286·85	24	5	152	9·12	14	4	152	6½–6½	1846·25
35,,	.....	....	....	286·9	26	5	87	8·89	14	4	87	....	1846·26
36	Cyc. 296..	7 29	104 09	125·6	8	4	152	7·51	8	4	152	7–7	1845·84
36,	.....	....	....	304·9	16	5	87	7·10	12	6	87	....	1845·85
37	Cyc. 301..	7 32·5	116 27	318 94	28	6	152	10·16	15	4	152	5½–5½	1846·25
37,	.....	....	....	318·6	23	5	152	9·83	15	4	152	....	1846·26
37,,	.....	....	....	319·0	25	5	87	....	..	..	..	....	1846·26
38	965 A.S.C....	7 45	136 02	103·1	10	4	152	59·52	8	4	152	4–10	1845·84
38,	.....	....	....	103·5	7	4	152	....	..	..	..	....	1845·91
38,,	.....	....	....	102·9	16	5	120	61·41	3	2	120	5–11	1846·31
39[e]	ζ Cancri AB	8 03·4	71 53	349·4	5	5	300	1·2	*	..	..	6–7	1845·83
39,[e]	.....	....	....	344·4	9	4	152	....	..	..	..	....	1846·29
39[e]	.....AC	....	....	148·0	12	4	300	4·85	8	4	300	7–7½	1845·83
39,[c]	.....	....	....	147·8	14	4	152	....	..	..	..	....	1846·29
40	.....	8 04·3	132 10	82·0	15	6	87	6·03	10	4	87	8½–9	1846·29
40,	.....	....	....	82·4	23	5	87	5·89	14	4	87	....	1846·29
41[e]	γ Argûs AB	8 04·8	136 53	218·0	10	3	152	41·38	16	4	152	2½–4½	1845·80
41,[e]	.....	....	....	218·7	12	3	152	42·25	8	4	152	2–5	1845·82
41,,[e]	.....	....	....	219·5	23	5	87	42·09	14	4	87	2½–5	1846·29
41[c]	.....AC	....	....	151·9	4	2	152	....	..	..	..	2½–9	1845·80
41,[c]	.....	....	....	151·4	11	3	152	63·39	8	4	152	2–9	1845·82
41,,[c]	.....	....	....	151·0	14	4	87	63·80	15	4	87	2½–9	1846·29
41,[d]	.....CD	....	....	122·3	8	3	152	33·69	4	4	152	9–11	1845·82
41,,[d]	.....	....	....	123·1	10	4	87	33·39	8	4	87	9–11	1846·29
42[e]	.....AB	8 38·5	142 31	309·6	22	5	87	77·13	4	2	87	5–5½	1846·21
42,[e]	.....	....	....	309·8	16	3	87	....	..	..	..	....	1846·24
42[b]	.....	....	....	266·2	6	3	87	62·04	2	2	87	5½–12	1846·21
42,[b]	.....	....	....	264·3	5	4	87	....	..	..	..	....	1846·24

34. Bright sunshine; stars slightly tremulous.

37. Are these variable? They seem much brighter than as given in the "Cycle;" there seems also to be a considerable retrograde motion.

39[e]. AB, not quite divided, but notched.

* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
43	ε Hydræ....	8 38·5	83 00	203·4	13	5	152	3·74	12	4	152	3½–8½	1846·26
43,	.....	....	....	202·9	20	7	152	....	..	..	..	....	1846·27
44	.....	8 44	129 52	204·8	12	5	87	4·	*	..	..	10½–10½	1846·29
44,	.....	....	....	208·1	13	5	87	3·5	*	..	..	11–11	1846·29
45	σ^4 Cancri....	8 52	57 09	136·8	20	5	152	4·48	8	4	152	6½–9	1846·31
45,	.....	....	....	137·5	12	4	87	4·48	9	4	87	....	1846·32
46	*s. f. b'* Argûs...	8 54	148 42	254·4	21	5	87	40·92	9	4	87	6½–8	1846·25
46,	.....	....	....	255·0	27	5	87	40·24	14	4	87	....	1846·25
47	.....	9 06·8	133 00	281·2	8	5	152	2·3	*	..	..	6½–6½	1845·88
47,	.....	....	....	285·9	12	5	152	2·4	*	..	..	....	1845·91
47„	.....	....	....	284·5	14	5	152	2·86	6	4	152	7½–8	1846·33
48	.....	9 30·5	138 16	200·2	15	5	152	2·62	8	4	152	7½–8	1846·25
48,	.....	....	....	202·8	13	5	152	2·77	8	4	152	....	1846·25
49	γ Leonis	10 11·4	69 23	105·3	14	4	152	2·95	8	4	152	2–3½	1845·82
49,	.....	....	....	105·1	7	3	152	....	..	..	..	....	1845·82
49„	.....	....	....	106·4	10	4	152	2·86	8	4	152	....	1845·84
50	941 La Caille..	10 25·5	142 57	29·4	24	5	87	17·53	20	6	152	6½–9½	1846·32
50,	.....	....	....	30·1	11	4	152	....	..	..	..	....	1846·32
51	940 La Caille..	10 25·6	134 16	217·1	25	5	87	13·57	13	4	87	6–6	1846·29
51,	.....	....	....	217·6	27	5	87	13·21	18	4	87	....	1846·29
52	ν Argûs	10 39	148 52	17·0	12	5	87	59·55	1	1	87	1–11	1845·88
52,	.....	....	....	15·8	13	5	87	61·54	8	4	87	....	1845·90
53	ξ Ursæ Maj.	11 10	57 36	136·9	23	7	152 / 300	3·28	14	6	300	3½–5	1845·81
53,	.....	....	....	134·8	23	5	152	2·95	16	6	152	....	1845·82
54	57 Ursæ Maj.	11 21	49 49	7·4	18	5	152	5·73	10	4	152	6–9½	1846·32
54,	.....	....	....	9·2	16	6	152	....	..	..	..	....	1846·32
54„	.....	....	....	8·7	10	4	120	5·18	10	4	120	....	1846·33
55*	α Crucis A C	12 18	152 11	....	..	..	..	89·56	10	4	87	2–5	1846·15
55,*	.....	....	....	202·3	10	4	152	88·81	2	2	152	....	1846·20
55„*	.....	....	....	201·8	11	3	87	....	..	..	..	....	1846·26
55*	.....	....	....	....	..	..	..	5·65	4	2	87	....	1846·15
55,*	.... A B	....	....	118·9	9	5	152	5·81	6	4	152	2–2	1846·20

44. A pair of small red stars about 4′ N.; a star 6m, which appears to be 804 La Caille: they will scarcely bear illumination.

45. This star seems pretty constant.

52. This star now almost vies with Canopus, and is decidedly brighter and redder than Arcturus.

52„ The star is now a little fainter, scarcely brighter than Arcturus; but there is a slight haze round the horizon.

54. The orbital motion of this star seems likely.

55,. Definition not very good.

* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
55,,*	α Crucis A B	....	....	120·8	12	5	87	5·72	10	4	87	....	1846·26
56	γ Virginis ...	12 34	90 36	182·3	20	5	152	3·06	10	4	152	3½–3½	1846·32
56,	.....	....	....	182·1	25	5	152	2·76	14	6	152	....	1846·32
57	1485 A. S. C. ..	12 45·6	146 21	17·05	25	5	87	35·65	12	4	87	5–6	1846·26
57,	.....	....	....	17·5	22	4	152	35·74	16	4	152	4½–5½	1846·29
57,,	.....	....	....	16·85	9	3	152	....	..	..	..	....	1846·31
58	Cor. Caroli	12 48·8	50 51	226·8	18	5	152	19·57	10	4	152	2½–6	1846·20
58,	.....	....	....	225·9	22	5	152	19·99	16	4	152	....	1846·31
59	1579 A. S. C. ..	13 43·0	122 15	111·10	27	5	152	8·20	15	4	152	5½–6½	1846·29
59,	.....	....	....	110·35	22	5	152	8·47	14	4	152	5–6½	1846·32
60	.....	14 27	135 30	25·2	12	5	152	19·24	8	4	152	7½–10½	1846·31
60,	.....	....	....	24·8	18	5	120	19·22	10	4	120	7–10½	1846·32
61	α Centauri ..	14 29·4	150 12	230·1	8	4	87	11·03	9	4	87	1–2½	1846·17
61,	.....	....	....	232·7	15	6	87	11·03	4	4	87	1–3	1846·20
61,,	.....	....	....	233·3	13	5	152	11·09	5	4	152	....	1846·20
61,,,	.....	....	....	232·5	13	5	87	10·70	12	4	87	....	1846·26
62	ζ Boötis	14 33·8	75 37	127·9	12	5	152	1·2	*	..	..	3½–4½	1846·15
62,	.....	....	....	126·2	15	5	152	1+	*	..	..	....	1846·22
63	ε Boötis	14 38·3	62 17	322·7	13	5	152	3·27	6	4	152	3–7	1846·20
63,	.....	....	....	323·9	14	5	152	3·64	10	4	152	....	1846·32
64	44 Boötis	14 58·7	41 45	236·7	12	4	152	4·05	8	4	152	5½–6	1846·15
64,	.....	....	....	236·3	18	5	152	4·40	9	4	152	....	1846·20
65	ε Lupi.....	15 01	138 11	144·8	19	5	152	27·39	9	4	152	5–7	1846·31
65,	.....	....	....	144·6	25	5	120	....	..	..	..	....	1846·32
66	η Lupi.....	15 50·2	127 59	21·1	12	4	152	14·42	6	4	152	3½–8½	1846·17
66,	.....	....	....	17·6	12	5	152	15·25	4	4	152	3½–9	1846·20
66,,	.....	....	....	21·1	16	5	152	15·65	4	2	152	4–8½	1846·40
67	.....	15 51	147 22	252·3	14	5	87	10·24	4	2	87	6–9	1846·26
67,	.....	....	....	251·7	12	5	120	9·52	8	4	120	5–10	1846·34
68*	51 Librae A B	15 55·9	100 57	19·2	5	4	152	1·0	*	..	..	5–5½	1846·15
68,*	.....	....	....	20·4	5	5	152	....	..	..	..	....	1846·17
68,,*	.....	....	....	29·9	9	5	152	....	..	..	..	....	1846·20
68*	.... A C	....	....	65·0	5	3	152	7·13	2	2	152	5–7½	1846·15

61 and 61,. Both yellowish.

66. A third star 11m; position, 154·5; δ a 9″·0. A, white.

66,. Sky hazy, but definition good. B, blueish.

65. Yellow.

* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
68,[c]	51 Libræ A C	....	....	67·2	4	3	152	....	..	..	..	....	1846·17
68,,[c]	.....	....	....	67·6	4	2	152	....	..	..	..	....	1846·20
69	σ Cor. Bor...	16 08·8	55 45	156·1	10	4	152	1·8	*	..	..	6½–7	1846·15
69,	.....	....	....	164·4	17	5	300	1·5	*	..	..	....	1846·22
69,,	.....	....	....	163·1	21	5	152	2·25	6	4	152		
70	σ Scorpii....	16 11·8	115 13	271·9	15	5	87	20·54	9	4	87	3–10	1846·22
70,	.....	....	....	272·4	19	5	152	20·58	10	4	152	....	1846·22
71[a]	.... A B	16 13·2	122 50	155·8	11	4	152	6·06	8	4	152	8–9	1846·17
71,[a]	.....	....	....	154·4	16	5	152	6·31	4	4	152	7½–7½	1846·20
71[c]	.... A C	....	....	87·0	3	1	152	93·3	1	1	152	7½–9	1846·20
72	.....	16 16·4	137 13	335·1	25	5	87	23·18	12	4	87	6–7½	1846·26
72,	.....	....	....	335·0	18	5	152	22·74	14	4	152	5½–7½	1846·33
72,,	.....	....	....	335·0	24	5	120	22·81	15	4	120	5½–8	1846·34
73[a]	ε Ophiuchi ..	16 16·4	113 05	1·1	13	5	152	3·86	13	4	152	3½–4½	1846·20
73,[a]	.... A B	....	....	0·7	14	5	87	3·58	12	4	87	5–5½	1846·22
73[c]	.... A C	....	....	1·1	13	5	152	152·2	2	1	152	3½–5	1846·20
73,[c]	.....	....	....	0·9	11	4	87	151·8	2	1	87	5–7	1846·22
73[d]	.... A D	....	....	253·8	3	1	152	11[s]·3 ((∂ ∞))	2	1	152	3½–5	1846·20
73,[d]	.....	....	....	253·8	9	2	87	11·1	2	1	87	5–7	1846·22
74	λ Ophiuchi ..	16 23·2	87 40	3·0	8	5	152	1	*	..	..	4–6	1846·22
74,	.....	....	....	3·5	19	7	152	....	..	..	..	....	1846·22
75	.....	16 30·6	138 27	264·8	18	5	87	10·22	10	4	87	6–7	1846·26
75,	.....	....	....	266·7	22	5	152	9·67	13	4	152	6½–7	1846·40
76	Cyc. 593 ..	16 48	109 17	231·0	18	5	87	5·31	6	4	87	7–8	1846·19
76,	.....	....	....	231·2	22	5	152	5·10	11	4	152	....	1846·40
77	36 Ophiuchi ..	17 05·9	116 22	215·4	11	4	152	4·95	8	4	152	4½–6	1846·17
77,	.....	....	....	216·0	19	5	87	4·77	10	4	87	5–5	1846·19
77,,	.....	....	....	217·1	14	5	87	4·57	12	4	87	5½–5½	1846·26
78	39 Ophiuchi ..	17 08·6	114 07	355·3	25	6	87	11·18	12	4	87	5–6	1846·20
78,	.....	....	....	355·4	20	5	87	11·02	13	4	87	....	1846·22
79	ζ Herculis ..	17 18·4	52 42	310·3	23	5	152	4·51	15	4	152	4½–6	1846·40

71,[c]. Sky hazy, but definition good.

73[a-c-d]. The magnitudes are evidently too high.

73,[a]. Is B variable? There certainly is not now a full magnitude between them.

74 and 74,. Taken by daylight; a wedge barely notched.

75. In a cluster of small stars.

77,. Are not these variable? They seem now exactly equal.

78. Daylight.

* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N. P. D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Date.
		h m	° ′	°				″					
80	Cyc. 627 ..	17 49·6	71 39	114·0	6	3	152	2·75	4	4	152	....	1845·72
80,	.....	....	....	113·8	16	5	152	2·95	8	4	152	8–8	1846·40
81	τ Ophiuchi ..	17 54·7	98 10	241·0	2	1	152	1·	*	..	..	5–6	1845·72
81,	.....	....	....	239·1	9	5	240	....	..	..	..	....	1846·34
82	70 Ophiuchi ..	17 57·7	87 27	120·3	15	5	300	6·69	8	4	300	4½–6	1845·81
82,	.....	....	....	120·7	18	5	87	6·69	8	4	87	....	1846·19
83	73 Ophiuchi ..	18 01·9	86 02	259·7	6	3	152	1·5	*	..	..	6–7½	1845·72
83,	.....	....	.. .	262·8	8	5	152	1·3	*	..	..	....	1846·34
84	2118 A. S. C. ..	18 16	110 37	299·1	6	3	152	1·6	*	..	..	....	1845·75
84,	.....	....	....	297·7	7	4	152	1·8	*	..	..	6–9	1846·33
84,,	.....	....	....	296·5	14	5	152	2·0	*	..	..	....	1846·34
85	ε Lyræ	18 39·2	50 29	21·8	6	3	152	....	..	..	..	5–6½	1845·75
85,	.....	....	....	21·9	12	5	152	3·75	9	4	152	....	1846·34
86	5 Lyræ	18 39·3	50 33	150·4	7	3	152	3·06	4	2	152	5–5½	1845·75
86,	.....	....	....	150·8	15	4	152	3·12	8	4	152	....	1846·34
87	β^1 Sagittarii ..	19 11	134 44	78·1	9	3	152	29·05	8	4	152	3–8	1845·84
87,	.....	....	....	77·5	22	5	152	28·02	14	4	152	4–7	1846·33
87,,	.....	....	....	78·6	15	4	152	28·30	11	4	152	4–7½	1846·34
88[a]	.... A B	19 30·3	100 42	329·2	6	3	152	20·32	2	2	152	9–10½	1845·83
88,[a]	.....	....	....	331·3	12	4	152	20·82	8	4	152	8½–10	1845·83
88[c]	.... A C	....	....	145·0	2	2	152	48·	*	..	..	8½–12½	1845·83
89	Cyc. 703 ..	19 30·5	100 32	316·4	17	6	152	3·5	*	..	..	....	1845·83
89,	.....	....	....	318·0	12	4	152	3·35	7	4	152	7½–9½	1846·34
90	e^1 Sagittarii ..	19 31·8	106 38	42·7	10	3	152	46·10	8	4	152	6–9	1845·77
90,	.....	....	....	41·5	8	3	87	45·40	22	6	87	5–9	1845·81
91	Prec[s]. 51 Aquilæ	19 42·0	101 08	319·7	6	3	152	30·80	4	2	152	10½–10½	1845·77
91,	.....	....	....	320·9	6	3	60	....	..	..	..	10–10	1845·81
92	.....	20 59·3	139 30	188·0	10	5	87	28·40	8	4	87	9–9½	1845·88
93	61 Cygni	....	....	99·8	8	4	87	16·02	12	4	87	6–6	1845·85
93,	.....	....	....	99·0	18	5	87	....	..	..	..	....	1845·89
94	.....	21 08·5	144 05	300·4	11	5	87	2·5	*	..	..	5½–9	1845·88
95[a]	.... A B	21 33·1	148 01	5·1	14	4	87	152·2	4	2	87	6½–6½	1845·88
95[c]	.... A C	....	....	220·6	9	3	87	205·4	4	2	87	6½–7	1845·88

87. A, gr. yellow.
87,. B, reddish purple.
88[a]. Reddish.
* Estimated.

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Ref. No.	Name or Designation of Star.	Right Ascension.	N.P.D.	Position.	Weight.	No. of Obs.	Power.	Dist.	Weight.	No. of Obs.	Power.	Magnitudes.	Dates.
		h m	° ′	°				″					
96	.....	21 38	138 00	9·2	18	5	87	31·63	8	4	87	7–9½	1845·87
96,	.....	....	....	10·5	22	6	87	30·66	12	4	87	....	1845·88
97	.....	22 17	132 13	....	10	5	152	44·00	4	4	152	7–8	1845·85
97,	.....	....	....	82·8	17	5	152	....	..	..	..	....	1845·85
98	ζ Aquarii...	22 20·9	90 48	348·8	14	5	87	3·20	8	4	87	4–4½	1845·87
98,	.....	....	....	347·3	13	5	87	....	..	..	..	....	1845·88
99[a]	θ Gruis A B .	22 58·5	134 23	12·1	16	6	152	2·5	*	..	..	4½–8½	1845·88
99,[a]	2758 A.S.C.	....	....	10·4	14	6	152	3·05	8	4	152	5–8½	1845·91
99[c]	..... A C	....	....	292·5	11	3	152	162·5	6	2	152	8½–8	1845·88
99,[c]	.....	....	....	292·9	9	3	152	161·5	6	2	152	....	1845·91
99[d]	..... C D	....	....	335·0	*	..	..	95·0	*	..	..	8–12	1845·91
100	Cyc. 829..	23 00·2	58 01	145·6	16	6	87	8·48	18	6	87	7–7½	1845·87
100,	.....	....	....	145·1	14	5	152	8·61	10	4	152	6½–8	1846·40
101[a]	Prec. ψ[1] Aquarii	23 05·0	99 44	177·0	17	6	87	25·83	8	4	87	8–8	1845·89
101,[a]	..... A B	....	....	177·1	14	5	60						
101[c]	..... A C	....	....	110·5	9	3	87	151·5	9	4	87	8–9	1845·89
101,[c]	.....	....	....	110·7	9	4	60						
102	ψ[1] Aquarii ..	23 07·8	99 55	311·7	8	3	87	48·53	4	2	87	5½–9	1845·92
103	.....	23 15·3	144 42	212·6	20	5	87	....	..	..	..	7–8	1845·87
103,	.....	....	....	211·8	21	6	87	26·26	12	4	87	....	1845·90
104	.....	23 19·0	141 09	91·8	15	5	87	48·12	6	4	87	8–8½	1845·87
104,	.....	....	....	91·5	17	5	87	47·46	4	4	87	....	1845·90
105	107 Aquarii ..	23 38·0	109 32	140·2	21	7	87	5·78	16	6	87	6½–6½	1845·88
105,	.....	....	....	140·8	16	5	87	....	..	..	..	....	1845·90
*106	Cyc. 819..	22 35	99 09	311·9	13	5	87	2·60	4	4	87	7½–8	1845·90
106	.....	....	....	311·6	21	6	152	3·24	6	4	152	....	1845·92
107	A.....	12 44·7	149 29										
108	.....	13 17·8	136 44										

99[a]. A, yellow.
99,[a]. B, orange.
99[c]. C, orange.
99[d]. D, blue?
99[d]. Is not D a nebula or a close double star?
103. A, yellow.
103,. B, greenish.
104. A, reddish.
104,. B, purple.
107. A curious cluster, a miniature of the *Hyades*, *s.f.* β *Crucis*; the place given is that of A, which is about 7 magnitude.
108. A large globular cluster, appearing to the naked eye like a blurred star 4 magnitude, a glorious object; completely resolved with 152, partially with 87; diameter about 10′.
* Estimated.

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Postscript by Capt. Jacob on the Orbits of Four Double Stars.

I have the pleasure to submit to the Society the orbits of four binary stars, as computed from all the observations accessible to me, including my own for the current year. To three of them the method of least squares has been applied in correcting the elements, after using, in the first instance, Sir J. Herschel's plan; but the orbit of *Castor* has been only roughly computed, as I do not consider the observations as yet sufficient to define the elements with precision. My only reason for trying it at all was, that the orbit given by Mr. Hind in December last does not exactly represent either my own observations, or those of Capt. Smyth of 1838 and 1843, and I wished to know the amount of alteration that would be requisite to bring these in. It will be seen that the chief difference is in *e*, and that not very great.

I hope in the course of a few years to be able to send an orbit for *α Centauri*, which is rapidly approaching its periastre, and will arrive there, I think, about 1855 or 1856, when the distance will probably not exceed 3″ or 4″; so that it will be a *magnified* likeness of *γ Virginis*, for the maximum distance is probably between 30″ and 40″, and the perihelion time above 500 years. This is all I can make out at present. Maclear's meridional observations of 1834 shew a decrease of distance, at present from 17″·8 to 10″·3, and of differential declination from 14″ to 6″, the angle having changed about 14° in the same time. It is rather remarkable regarding *γ Virginis*, that all the orbits persist in giving a minimum distance of about ½″, and yet the stars were seen as one, perfectly round, and for the space of several months, in the best telescopes that were pointed at them, even in Herschel's twenty-feet reflector, and the clear atmosphere of the Cape. Can this be accounted for by the brightness of the stars? At any rate, I think it can scarcely be said to be yet *proven* that the laws of gravity are absolutely unaltered at these remote distances. A similar remark might be made regarding *ξ Ursæ*, whose errors are of enormous magnitude considering the easiness of the star; in the comparisons the larger errors have been purposely selected, to shew how the adjacent ones compensate each other.

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Castor.

Perihelion passage = 1703·30.

		Date.	Comparison. l_c	$l_c - l_o$	ϱ_c	$\varrho_c - \varrho_o$
π =	10°00′					
Ω =	10 00	1759·80	323° 47′	− 73′		
λ =	0 00	1802·08	282 46	− 1		
γ =	43 17	1816·97	270 00	+ 9		
e =	0·300	25·75	....	....	4″·59	−0″·09
n =	−0°·5512	1830·59	259 40	+ 17	4·73	+0·01
P =	653ᵐ·1	1837·35	255 06	+ 15	4·77	+0·08
a =	6″·30	1846·34	250 23	− 40	5·09	+0·04

ξ Ursæ.

Perihelion passage = 1816·66.

		1781·97	143° 47′	− 9′		
		1802·09	97 31	− 66		
		1819·10	284 33	+ 23	2″·56	−0″·85
Apparent Orbit.	π = 311°45′	1822·08	262 39	+ 55		
Dist. Position.	Ω = 96 06	1823·29	258 27	−146	2·81	−0·81
″ °	λ = 230 32	1827·27	228 17	+150	1·79	+0·16
Max., 3·43 110·5	γ = 53 52	1828·64	223 16	−107	2·00	−0·06
Max.„ 2·00 253	e = 0·4116	1830·94	207 30	− 96	1·80	+0·12
Min., 1·01 356	n = −5°·885	1831·17	201 03	+197	2·01	−0·08
Min.„ 1·93 211·5	P = 61ᵐ·175	1832·29	196 54	0	1·90	+0·50
	a = 2″·82	1837·28	165 30	+142	1·80	+0·42
		1838·48	164 42	−155	2·10	+0·21
		1843·16	143 12	+ 24	2·30	+0·44
		1845·82	135 54	− 17	3·11	−0·13

γ Virginis.

Perihelion passage = 1836·30.

		1781·89	130° 44′	+55′	5″·70	+0″·21
	π = 316°52′	1803·20	120 19	+18		
	Ω = 69 40	1822·25	103 24	−18	3·79	−0·55
	λ = 249 18	1828·35	90 30	−17		
Max. 6″·02 136°	γ = 24 36	1831·33	77 44	+ 5	1·86	−0·20
Min. 0·47 328	e = 0·8525	1834·30	47 09	−32	0·90	−0·01
	n = −2°·674	1837·21	265 24	+28	0·60	+0·02
	P = 133ᵐ·5	1839·40	217 12	+53	1·00	+0·16
	a = 3″·499	1843·33	191 36	− 3	1·90	+0·08
		1846·32	182 12	−20	2·89	−0·41

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70 *Ophiuchi.*

Perihelion passage = 1807·60.

Apparent Orbit.	Dist.	Position.
	"	°
Max.,	6·71	119
Max.,	2·56	326
Min.,	1·89	233
Min.,	2·41	0

π	=	293° 17′
Ω	=	128 33
λ	=	156 20
γ	=	51 30
e	=	0·482
n	=	−4°·113
P	=	87ʸʳ·52
a	=	4″·675

Date.	Comparison. θ_c	$\theta_c-\theta_o$	ρ_o	$\rho_c-\rho_o$
	° ′	′	″	″
1779·77	90 00	+17	4·49	+0·37
1802·34	334 38	−90	2·56	−0·00
1821·51	156 50	+71	4·30	−0·44
1827·40	143 54	−33	4·51	+0·59
1830·50	137 28	+37	5·65	−0·03
1832·57	135 31	−29	5·50	+0·39
1835·56	130 36	+28	5·97	+0·27
1838·51	126 30	+62	6·25	+0·23
1842·55	122 24	+34	6·68	−0·01
1846·21	120 10	−70	6·83	−0·12

W. S. JACOB.

POONAH, November 14, 1846.

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X. *Description of an Astronomical Observatory at Camden Lodge, near Cranbrook, Kent. By the Rev. W. R. Dawes.*

Read December 11, 1846.

In the autumn of 1845 I erected, in the grounds of my present residence, a small observatory, a brief description of which I beg to present to the Astronomical Society.

In the erection of the building my principal object was to secure perfect dryness, and a speedy equalisation of the interior and exterior temperature. With a view to the first of these requisites, the foundation has been excavated about eighteen inches below the level of the soil, and the boarded floor elevated twelve inches above it: several air-bricks, or gratings, being introduced on all sides to insure a free circulation of air under the floor. On the foundation walls, which rise to the surface, large blocks of stone are laid, in the top of which, at intervals of about three feet, mortices are cut to receive the tenons at the lower end of strong upright posts of fir-wood, the tenons at the upper end of the same being inserted into mortices in the circular wall-plate. These posts are strengthened by stout diagonal braces, also of fir, extending from the bottom of each post nearly to the top of the adjacent post on each side; thus forming a very firm frame-work. Exterior to this is nailed a sheathing of half-inch pine boarding, tongued and grooved; and over all a covering of stout canvass, laid on upon a thick coat of paint while wet, and immediately covered with another coat on the outside, on which was dusted fine sand in such quantity as the paint would retain. These walls are perfectly weather-proof.

The observatory is divided into two apartments, a transit-room and an equatoreal-room. The slit in the roof of the transit-room is eighteen inches wide, and is closed by a shutter on hinges, which, when open, is kept so by

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two weights suspended by small chains passing over pulleys placed on the edge of the roof; but it is prevented from swinging beyond the perpendicular position by two rods of oak, extending from the edge of the shutter to the pulleys.

The roof of the equatoreal-room is a nearly hemi-spherical dome. In its general construction it is similar to the dome of Mr. Lassell's observatory at Starfield, described and illustrated by a drawing in Vol. XII. of the Society's *Memoirs*. The interior diameter of the dome-curb is 13 feet 4 inches. The slit is nearly 30 inches wide, and extends rather beyond the apex of the dome. It is closed by a quadrantal shutter divided horizontally into two portions, which are drawn up by cords passing over a roller placed near the apex of the dome, and slide down within the sheating on the opposite side.

On the top of the wall-plate is fixed a circular iron channel, cast in portions of about 3 feet long. The radius of concavity of the channel is 3 inches. A similar channel is fixed under the curb of the dome; and between the two are placed three iron balls, whose radius is 2¼ inches. These move freely, and with so little friction, that the dome is readily turned by pulling a cord attached to the dome curb. The covering of the dome and of the roof of the transit-room is similar to that of the walls; but an additional coat of paint has been laid on over the sand, to prevent its being detached by the wind, and carried into the observatory. The space between the wall-plate and the dome-curb is covered externally with a curtain of floor-cloth. The interior temperature is speedily reduced to nearly the same point as the exterior, in consequence of the small substance of the walls and roof, which retain very little heat after even the hottest day.

The instruments in the observatory are a transit-circle, a clock, and an achromatic refractor mounted equatoreally.

The transit-circle is 2 feet in diameter, divided by hand on silver to five minutes, and subdivided to single seconds by the micrometer microscopes, four in number, occupying the extremities of two diameters of the circle. The telescope, which possesses great excellence, has an aperture of 2¼ inches, and a focus of about 30 inches, and is furnished with five eye-pieces, magnifying from 27 to 123 times. The highest power is almost constantly employed, both for transits and for angular measurements. This beautiful and efficient little instrument was made by Mr. Simms, for E. B. Beaumont, Esq., from whom I purchased it. It is mounted on stone piers, which rise 4 feet

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3 inches above the floor, and stand on a mass of stone resting on the solid, undisturbed clay forming the subsoil. It is sufficiently steady, and preserves its adjustments well. The microscopes are firmly attached to a stout stone fork, forming part of the top of the western pier. The circle is not designed for reversion, but arrangements are made for observing by reflexion. This, however, is resorted to only for the determination of the latitude of the observatory. Declinations of unknown objects are obtained *differentially*, by comparison with stars whose places have been well determined, and especially with the Greenwich stars in the *Nautical Almanac*.

In consequence of the imperfection of my hearing, I found it needful by some means greatly to increase the loudness of the clock-beat. To accomplish this, Mr. EIFFE has applied to it his *loud beat*, which is perfectly effectual, and enables me to hear the clock distinctly while observing, not only with the circle, but also with the equatoreal. This is a valuable acquisition; and, as the loud beat is put in action only during the time of a transit, it produces no perceivable difference in the clock-rate.

Intending that the equatoreal telescope should have an aperture of 6 or 7 inches, I applied to Mr. DOLLOND for such a one; but, unfortunately, he had not at that time sufficiently perfect materials whereof to construct it. Professor STRUVE having visited this country soon afterwards, I was induced by his representations to give an order to Messrs. MERZ and MAHLER, successors to UTZSCHNEIDER and FRAUNHOFER, at the Optical Institute in Munich. The size determined on was an aperture of 6 inches and focus of 8 feet, Paris measure. As an object-glass of first-rate excellence was requisite, it was considered only fair to these eminent artists that they should furnish every part of the mounting, notwithstanding some grave objections to the German method of equatoreal arrangement. Owing to the death of one of the partners, M. MAHLER, and some vexatious legal proceedings consequent thereon, the completion of the instrument was delayed about ten months beyond the time fixed on, and it did not arrive till near the end of last September. The arrangement of the equatoreal mounting is almost precisely similar to that by FRAUNHOFER at Dorpat, except that for the cumbrous wooden stand of that instrument is substituted a massive stone pier, much to the advantage of the instrument and the comfort of the observer. The declination axis is 7 feet 6 inches from the floor, and the eye-piece 3 feet 6 inches when the telescope is directed to the zenith. The telescope being

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accurately counterpoised in all positions, and nearly the whole weight at the upper end of the polar axis supported upon friction rollers, its motions in every direction are quite as easy as is desirable. The clock-work is extremely steady and uniform, the regulation being effected by the friction of small brass balls against the inside of an inverted frustrum of a cone. The most serious objection which has been urged against the German style of equatoreal mounting is, that when during the observation of a celestial object the object arrives at the meridian, it is necessary to turn the telescope on the declination axis to the same polar distance on the opposite side, and to turn the polar axis 180°. This objection, however, applies only in a very small degree to the instrument in my possession, including only those objects which lie between 50° and 80° of north declination; and these, being circumpolar, may be more commodiously observed in other situations than close to the meridian; so that, practically, no inconvenience is experienced. It must be acknowledged, however, that in latitudes within 30° of the equator this objection would be of more weight.

The hour circle is divided on silver to single minutes of time; and the two opposite verniers read to 4 seconds, and by easy estimation to 1 second. The declination circle is divided, also on silver, to 10 minutes, and its two opposite verniers read to 10 seconds, and by estimation to 5 seconds or less.

The repeating, or parallel wire, micrometer is a beautiful piece of workmanship. The position circle is read by each of its two verniers to single minutes. By an ingenious and very efficient contrivance the webs may be illuminated in a dark field; the direction of the illuminating ray with respect to that of the webs being variable at pleasure.

The telescope has a clear aperture of $6\frac{1}{2}$ inches, and a focal length of $8\frac{1}{2}$ feet, English measure. The Huyghenian eye-pieces furnished with it magnify from 85 to 585 times; and the positive eye-tubes of the micrometer from 120 to 690 times. There is also a double annular micrometer, whose eye-piece magnifies 65 times. From its performance under the best circumstances we have had during the late unsettled weather, it may safely be said that the telescope possesses first-rate excellence, uniting great sharpness of definition with extraordinary brilliance. As severe tests of its performance, several of the double stars in the Pulkowa Catalogue, found with the refractor of 15 inches' aperture, have been examined, and every one of them set down in that catalogue as of one second central distance by estimation, has been

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distinctly resolved. The following difficult objects have been satisfactorily measured in position: *η Coronæ*, *μ*² *Boötis*, 7 *Tauri* A & B, *δ Cygni*, *ζ Herculis*, and *γ*² *Andromedæ*. Measures of some of these will be annexed to this communication, as they are objects of special interest. The two very faint stars in the trapezium in *Orion's* nebula have now become well known as a fine telescopic test, especially that near the brightest of the group, and usually called the *sixth* star. Both these were steadily seen on November 1, and again on November 3. The *fifth* star (the preceding one of the whole group) was visible with powers from 125 to 812 (a double convex lens); the *sixth* was steadily seen with powers 125, 195, and 282; occasionally with 425 and 585: but the best power for both was 195. I give these particulars of the observation, because I cannot but think that these stars must be increasing in brightness; and I beg to recommend them to the notice of observers, as being very interesting objects.

Of *γ*² *Andromedæ* I obtained the following measures on October 23:—

Power.	Obs. Angle.	Weight.
435	279° 47′	4
	282 21	5
	283 18	6
	280 40	6
	279 30	6
572	282 21	6
	284 19	4
	280 46	7
	281 7	6
Mean	281 34	
	− 180 0	
	101 34	
Zero correction +	11 45	
Angle of Position .	113 19	50

The star presented a good measurable elongation, in best moments *notched*. Central distance estimated at 0″·6. Both the components are precisely of the same colour —a greenish blue.

For comparison of this result with previous ones, we have—

1842·72	P = 126°	36′	Struve, with Pulkowa refractor.
1842·83	125	48	Dawes, with Mr. Bishop's telescope.
1843·33	120	0	Smyth.
1846·81	113	19	Dawes, as above.

Notwithstanding the difficulty of the object, this series renders it extremely probable that we have here a most beautiful binary system.

ζ Herculis.	1846·79	P = 112° 44′	obs. 3	weight, 13	power, 322
	·82	112 5	6	48	435
	·88	112 17	5	25	260

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The mean, allowing weights, is 112° 14′. This result shews a variation of position amounting to 30° 44′ since my measures of this star at Mr. Bishop's observatory, in 1841. The last of the three sets recorded above was obtained when the star was within a few minutes of the meridian, the sun being little more than half an hour past it.

η Coronæ.	1846·88	P = 196° 46′; obs. 6; weight, 29. Easily measured with 435.
μ² Boötis.	1846·80	P = 283° 49′; obs. 5; weight, 18. Separable with 322, but extremely unsteady.
7 Tauri A, B.	1846·91	P = 259° 55′; obs. 3; weight, 16. Decidedly *notched*, but usually very unsteady. Probably binary.
ϑ Cygni.	1846·79	P = 16° 46′; obs. 5; weight, 19; power, 322. Occasionally well seen.

The webs at present in the micrometer being too thick for the accurate measurement of very delicate objects *in distance*, I am not able to give the distances of any of these objects.

A very useful article of furniture in the equatoreal-room is a *Reclinia*, invented by Henry Lawson, Esq. F.R.A.S., for which the silver medal of the Society of Arts was awarded. It is of the smaller kind described and sketched in his *Arrangement of an Observatory*. For long-continued observations, in which it is desirable that the observer should be preserved from the unsteadiness and fatigue produced by an awkward posture, it is very valuable, being productive of great comfort to the observer, and highly conducive to accuracy in the results. The ingenuity and simplicity of its construction, and its perfect adaptation to its object, strongly recommend it to general use. Mine was made under Mr. Lawson's superintendence, by C. and W. Roper, of Bath, and is an excellent piece of workmanship. With my telescope it is adapted to all altitudes of the object from 30° to 90°.

A few observations have been made with the meridian circle by direct and reflected vision, for the determination of the latitude of the observatory; but as neither this nor the longitude is finally settled, I can only state, that the assumed longitude is $2^m\ 12^s$ east of Greenwich, and the assumed latitude 51° 6′ 32″ N.

W. R. DAWES.

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XI. *On a proposed Alteration of* BESSEL'S *Method for the Computation of the Corrections by which the Apparent Places of Stars are derived from the Mean Places. By G. B.* AIRY, *Esq. Astronomer Royal.*

Read January 8, 1847.

THE method of computing the corrections for the places of stars, introduced by BESSEL and adopted in the Catalogues of the Astronomical Society and the British Association, was undoubtedly a great improvement upon the methods which preceded it. Although referring less clearly to the origin of the various parts of the corrections, yet by collecting into distinct terms (admitting of easy preparation for an ephemeris) those parts which depend on the time, and collecting into corresponding terms those factors (admitting of easy tabulation in a star-catalogue) which depend on the place of the star, it produced a degree of simplicity which formed a remarkable contrast with the complexity of the steps in the former methods.

Nevertheless, this method is not without inconvenience. When calculations are to be made, not for successive places of a single star, but for the irregularly occurring observations of stars in all parts of the heavens, as frequently happens in the actual practice of an observatory, the number of changes of sign is very great. During two periods in every year A is negative; during one period in every year B is negative; during one period in each year of half the whole number, C and D are negative; and the signs of a, b, d, a', b', c', d', have every possible change. In consequence of this, the most incessant attention is necessary to insure correctness of signs in the products, and in the sums of the products; and in spite of every care, a greater number of errors is produced by this cause than by any other.

It has long been with me a matter of earnest desire to put these corrections in a shape in which no change of signs should occur, except, of

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course, in the very last step by which the final result (essentially admitting of change of sign) is exhibited. The method which I now submit to the Society does completely attain this object. Whether the advantage is counterbalanced by accompanying disadvantage, the Society will best judge. In my own opinion, the advantage greatly exceeds the disadvantage for catalogued stars, but may be exceeded by it for uncatalogued stars.

I shall now proceed to explain the method.

(1.) If we put

$$\begin{aligned} A &= -18{\cdot}732 \cdot \cos \odot \\ B &= -20{\cdot}420 \cdot \sin \odot \\ C &= t - 0{\cdot}025 \cdot \sin 2\odot - 0{\cdot}343 \cdot \sin \mathfrak{N} + 0{\cdot}004 \cdot \sin 2\mathfrak{N} \\ D &= -0{\cdot}545 \cdot \cos 2\odot - 9{\cdot}250 \cdot \cos \mathfrak{N} + 0{\cdot}090 \cdot \cos 2\mathfrak{N} \end{aligned}$$

where $\odot$ is the sun's longitude, $\mathfrak{N}$ the longitude of the moon's ascending node, and t the fraction of a year; and if we put

$$\begin{aligned} a &= \tfrac{1}{15} \cos \alpha \cdot \sec \delta \\ b &= \tfrac{1}{15} \sin \alpha \cdot \sec \delta \\ c &= 3{\cdot}0706 + 1{\cdot}3370 \sin \alpha \cdot \tan \delta \\ d &= \tfrac{1}{15} \cos \alpha \cdot \tan \delta \\ a' &= -\tan \omega \cdot \cos \delta + \sin \alpha \cdot \sin \delta \\ b' &= -\cos \alpha \cdot \sin \delta \\ c' &= -20{\cdot}055 \cdot \cos \alpha \\ d' &= \sin \alpha \end{aligned}$$

where α is the star's right ascension, δ its declination estimated positive when north, and ω the obliquity of the ecliptic; then

The correction to the star's right ascension in seconds of time

$$= Aa + Bb + Cc + Dd.$$

The correction to the star's north polar distance in seconds of arc

$$= Aa' + Bb' + Cc' + Dd'.$$

(2.) The greatest negative value of A is $-18{\cdot}732$; that of B is $-20{\cdot}420$; that of C is $-0{\cdot}4$ nearly; and that of D is $-10{\cdot}0$ nearly.

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The greatest negative value of a' is $-1{\cdot}1$ nearly; that of b' is $-1{\cdot}0$; that of c' is $-20{\cdot}055$; and that of d' is $-1{\cdot}0$.

The greatest negative values of a, b, c, d, cannot be assigned without a limitation of declination. If, however, we suppose the greatest value of tan δ or sec δ to be 15, which will include all stars except those within $3^\circ\,45'$ of the poles, then the greatest negative value of a will be $1{\cdot}0$; that of b will be $1{\cdot}0$; that of c will be less than $24{\cdot}0$; and that of d will be $1{\cdot}0$.

(3.) If now we add to A, B, &c., a', b', &c., a, b, &c., positive numbers equal in magnitude to those which I have stated, or exceeding them, the sums will be always positive. Among the numbers which we may choose for this purpose, it appears to me that there are two distinct classes which deserve the preference above all others, and between which our election is to be made. In one of these classes, those numbers would be added which exactly destroy the maximum negative value: thus to $-18{\cdot}732 \cos \odot$ we should add $18{\cdot}732$; which produces $18{\cdot}732\,(1-\cos \odot)$ or $37{\cdot}464 \sin^2 \frac{\odot}{2}$. The advantage of this is, that the sum is a simple trigonometrical function: the disadvantage is, that it produces figures with many decimals in the new terms which our new method will introduce. In the other class, numbers of a convenient form may be chosen, and the same numbers, as far as possible, will be added throughout. Thus, six of the twelve numbers may be rendered always positive by adding $1{\cdot}2$, and the remaining six numbers may be rendered always positive by adding 25. This method introduces round numbers in our new terms; but for the formation of our new numbers from the numbers already computed we must prepare two auxiliary Gaussian tables: one of the form, Given log A, to find log $\overline{25+\mathrm{A}}$, and the other of the form, Given log C, to find log $\overline{1{\cdot}2+\mathrm{C}}$. I prefer the adoption of the second class of additive numbers.

(4.) Let, therefore,

$$\begin{aligned} \mathrm{E} &= \mathrm{A} + 25 \\ \mathrm{F} &= \mathrm{B} + 25 \\ \mathrm{G} &= \mathrm{C} + 1{\cdot}2 \\ \mathrm{H} &= \mathrm{D} + 25 \\ e &= a + 1{\cdot}2 \\ f &= b + 1{\cdot}2 \\ g &= c + 25 \\ h &= d + 1{\cdot}2 \end{aligned}$$

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$$e' = a' + 1{\cdot}2$$
$$f' = b' + 1{\cdot}2$$
$$g' = c' + 25$$
$$h' = d' + 1{\cdot}2.$$

Then the correction to right ascension, in seconds of time, is

$$\begin{aligned}&(\mathrm{E}-25)\times(e-1{\cdot}2)\\+&(\mathrm{F}-25)\times(f-1{\cdot}2)\\+&(\mathrm{G}-1{\cdot}2)\times(g-25)\\+&(\mathrm{H}-25)\times(h-1{\cdot}2)\end{aligned}$$

And the correction to north polar distance, in seconds of arc, is

$$\begin{aligned}&(\mathrm{E}-25)\times(e'-1{\cdot}2)\\+&(\mathrm{F}-25)\times(f'-1{\cdot}2)\\+&(\mathrm{G}-1{\cdot}2)\times(g'-25)\\+&(\mathrm{H}-25)\times(h'-1{\cdot}2)\end{aligned}$$

(5.) Performing the multiplications, we find the correction to the right ascension, in seconds of time, is

$$\begin{aligned}&120{\cdot}0+\mathrm{E}e+\mathrm{F}f+\mathrm{G}g+\mathrm{H}h\\&\quad-(\mathrm{E}\times1{\cdot}2+\mathrm{F}\times1{\cdot}2+\mathrm{G}\times25+\mathrm{H}\times1{\cdot}2)\\&\quad-(e\times25+f\times25+g\times1{\cdot}2+h\times25)\end{aligned}$$

and the correction to the north polar distance, in seconds of arc, is

$$\begin{aligned}&120{\cdot}0+\mathrm{E}e'+\mathrm{F}f'+\mathrm{G}g'+\mathrm{H}h'\\&\quad-(\mathrm{E}\times1{\cdot}2+\mathrm{F}\times1{\cdot}2+\mathrm{G}\times25+\mathrm{H}\times1{\cdot}2)\\&\quad-(e'\times25+f'\times25+g'\times1{\cdot}2+h'\times25)\end{aligned}$$

where it is to be observed that the quantities E, F, G, H, $e, f, g, h, e', f', g', h'$, are necessarily positive; that the second collection of terms within the bracket in each formula is also necessarily positive, and depends only on the day; and that the third collection of terms within the bracket in each formula is also necessarily positive, and depends only on the star.

Let
$$\mathrm{E}\times1{\cdot}2+\mathrm{F}\times1{\cdot}2+\mathrm{G}\times25+\mathrm{H}\times1{\cdot}2=\mathrm{K}$$
$$e\times25+f\times25+g\times1{\cdot}2+h\times25=k$$
$$e'\times25+f'\times25+g'\times1{\cdot}2+h'\times25=k'$$

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then the correction to the right ascension, in seconds of time, is

$$120^{s}\cdot0 + Ee + Ff + Gg + Hh - (K + k)$$

and the correction to the north polar distance, in seconds of arc, is

$$120''\cdot0 + Ee' + Ff' + Gg' + Hh' - (K + k').$$

The greatest possible value of K is about 195; and those of k and k' are about 190. Let $L = 210 - K$, $l = 210 - k$, $l' = 210 - k'$; or,

$$\begin{aligned} L &= 210 - \{E \times 1^{s}\cdot2 + F \times 1^{s}\cdot2 + G \times 25 + H \times 1^{s}\cdot2\} \\ l &= 210 - \{e \times 25 + f \times 25 + g \times 1^{s}\cdot2 + h \times 25\} \\ l' &= 210 - \{e' \times 25 + f' \times 25 + g' \times 12 + h' \times 25\} \end{aligned}$$

then the correction to the right ascension, in seconds of time, is

$$Ee + Ff + Gg + Hh + L + l - 300^{s}\cdot00$$

and the correction to the north polar distance, in seconds of arc, is

$$Ee' + Ff' + Gg' + Hh' + L + l' - 300''\cdot00$$

in which formulæ every one of the quantities denoted by a letter is necessarily positive at all times.

(6.) It is unnecessary to point out the easiest way of computing L, l, and l'; it is sufficiently clear that they will cost very little trouble.

The ephemeris will only require one additional column; and the star catalogue will require two additional columns. The arrangement of the ephemeris will be—

Day.	Log E.	Log F.	Log G.	Log H.	L.

and that of the two portions of the star catalogue will be—

Star's Name.	Log *e*.	Log *f*.	Log *g*.	Log *h*.	*l*.

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and—

Star's Name.	Log e'.	Log f'.	Log g'.	Log K'.	l'.

in no part of which will an algebraical sign occur.

(7.) It is now necessary to examine what number of decimal places would be necessary for log e, log f, &c., log e', log f', &c. And first, with regard to north polar distances. If we have logarithms to four figures, an error of half a unit in the last place (which is the limit of possible errors) produces in the number computed an error of $\frac{1}{8686}$ of the whole number. The largest number to be computed will be about 54·0; therefore the greatest error will be $\frac{54}{8686}$, or less than 0·01. As the unit here is the second of arc, this error is quite unimportant; and it will therefore suffice that log e', log f', &c., be given accurately to four places of decimals.

(8.) With regard to right ascensions, the same calculation applies; that is, the greatest error in the result of each logarithmic multiplication, if logarithms of four figures were used, would be $\frac{54}{8686}$, or 0·0062. But the unit here is the second of time. Although this error might be neglected for a single computation, yet, when it is considered that the results of four such computations are to be added together, that the error of the sum may therefore amount to $0^s{\cdot}02$, and this error cannot be removed by any care of the computer, but is subject to possible increase from any imperfection in his method of taking out the numbers corresponding to the logarithms, it will be evident that the accuracy of this calculation is scarcely sufficient, and that five figures must therefore be used. Log E, log F, log G, log H, log e, log f, log g, log h, must therefore be computed to five decimal figures. It is to be remarked that, in all these cases in which the necessity for the fifth figure can become sensible, logarithms of a, b, c, d, to four figures will give with accuracy logarithms of e, f, g, h, to five figures.

(9.) The preceding arrangements apply entirely to catalogued stars, and I trust it will appear that, with regard to these, a very considerable advantage is gained by the new shape suggested for the computation. For uncatalogued stars

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it is not so, if we make use of the given place of the star, as defined by right ascension and declination, for immediate computation of the trigonometrical functions expressing a, b, &c. It would be necessary to compute separately

$$\begin{aligned} &\mathrm{E}\times\tfrac{1}{15}\cos\alpha\,.\,\sec\delta - 25\times\tfrac{1}{15}\cos\alpha\,.\,\sec\delta \\ +&\mathrm{F}\times\tfrac{1}{15}\sin\alpha\,.\,\sec\delta - 25\times\tfrac{1}{15}\sin\alpha\,.\,\sec\delta \\ +&\,\&\mathrm{c.} \qquad\qquad -\,\&\mathrm{c.} \end{aligned}$$

But here it will be found most convenient to compute the new star-constants as for catalogued stars, and to treat the uncatalogued stars exactly as catalogued stars. As the log $\left(\frac{1}{15}\cos\alpha\,.\,\sec\delta\right)$ or log a must be computed, the calculator with a table of log $(1{\cdot}2+a)$ at hand will at once convert it into log e; and so for the others. The trouble will, for a single observation of an unknown star, be undoubtedly greater than by the use of the formula $\mathrm{A}a+\mathrm{B}b+\mathrm{C}c+\mathrm{D}d$; but when the same star is observed two or three times, the trouble on the new system will be less than on the old system.

G. B. AIRY.

Royal Observatory, Greenwich,
January 14, 1847.

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XII. *Reduction of the Observations of* HALLEY'S *Comet made at the Cambridge Observatory in the years* 1835 *and* 1836. *By G. B.* AIRY, *Esq. Astronomer Royal.*

Read January 8, 1847.

IN the autumn of 1835 and the commencement of 1836 an extensive series of observations on HALLEY'S comet was made at the Cambridge Observatory. The greater part of these were made with the equatoreal. The observations were reduced at the time as far as was then practicable, and with notice of every correction which appeared necessary. The errors of the instrument were omitted, as it was known that all which admitted of being reduced to law were very small; but the corrections for refraction (when necessary) and parallax were applied. In this state the observations and reductions are published in the Cambridge Observations, 1835. As far as the constancy and correctness of position of the instrument could be assumed, sufficient means were given for the complete reduction of the observations. If this assumption were not made, reliance must be placed on the differential observations with small stars, for which a knowledge of the places of these stars would be necessary.

In the years 1836 and 1837 the small stars of comparison were observed at Greenwich, as far as it was possible to see them. A few eluded every attempt, although sought for, as it appears, with the greatest care. The remainder will, however, it is presumed, be amply sufficient to establish all the results which can be drawn from these observations in fixing the comet's places and the errors of the ephemeris with which they are compared.

In exhibiting the results of the observations, it has appeared desirable to make use of both the methods above alluded to. If the observations of the small stars were in all cases free from unusual error, the differential deter-

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mination would undoubtedly be much preferable to those depending on index-error of the instrument. But the stars which it was possible to find in the vicinity of the comet were sometimes so faint that accurate observation was impracticable; and the results will sufficiently shew that, in some cases, the error of observation of these stars was greater than any instrumental error, or even than any error of observation of the comet.

The ephemeris with which the comparisons are made is that alluded to in the introduction to the Cambridge Observations, 1835, as circulated by the Superintendent of the *Nautical Almanac*, under the date 1835, Dec. 30. This ephemeris (in regard to the places unaffected by perturbation) appears to be precisely equivalent to that printed in the Appendix to the *Nautical Almanac* of 1839, with this difference only, that it gives right ascensions in time instead of arc. I am happy to take this opportunity of correcting an error in the Introduction to the Cambridge Observations, 1835, page lxiv. I had inadvertently supposed that the places in that ephemeris were unaffected by aberration. I am informed, however, by the Superintendent of the *Nautical Almanac*, that aberration was fully included, and, therefore, that (perturbations and errors of elements excepted) the ephemeris is immediately comparable with observations.

I have thought it unnecessary at present to group the observations, and to form equations for the immediate correction of the elements of the comet's orbit. It is our duty as early as possible to clear the observations of the errors due to instrumental error, to atmospheric effects, and to terrestrial locality, as well as of the obscurities due to our arbitrary selection of stars of comparison; and to give every facility to the ultimate use of the observations by comparing the corrected results with the admirable ephemeris in our hands. But when the same thing has been done with the observations made at other observatories, especially those of the southern hemisphere, the task of combining the results will best be left to the industry and the judgment of some future Rosenberger, who, with the whole before him, may safely venture on bringing the whole to consistency and completeness, by expunging the results which are manifestly bad, and by filling up from the observations of one place the lacunæ which accident, or bad weather, or geographical position, has caused in those of another place.

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Section I.

Catalogue of the Mean Places of the Stars with which the Comet was compared in the Observations with the Equatoreal and the Mural Circle.

Reference in Cambridge Observations, 1835.	Authority for Right Ascension.	Mean Right Ascension, 1835, Jan. 1.	Authority for North Polar Distance.	Mean N.P.D. 1835, Jan. 1.
		h m s		° ′ ″
139 Tauri	Camb. Obs. 1835	5 47 45·61	Camb. Obs. 1835	64 4 29·26
2 Geminorum ...	Gr. Obs. 1836	5 56 45·17	, , , ,	66 21 16·01
A	, , , ,	6 8 59·22	.....	.....
B	, , , ,	6 11 29·99	Camb. Obs. 1835	59 58 4·81
48 Aurigæ	, , , ,	6 17 57·59	Gr. Obs. 1836	59 24 49·09
C	Gr. Obs. 1837	6 19 21·99	.....	.....
D	, , , ,	6 19 49·92	.....	.....
E	, , , ,	6 21 40·32	.....	.....
A.S.C. 808	Gr. Obs. 1836	6 21 41·14	Gr. Obs. 1836	57 26 2·27
F	Gr. Obs. 1837	6 22 53·02	Camb. Obs. 1835	56 51 47·27
G	.....	.....	Gr. Obs. 1837	55 20 50·13
H	Gr. Obs. 1837	6 26 22·95	.....	.....
I	.....	.....	Camb. Obs. 1835	55 23 25·37
J	Gr. Obs. 1837	6 26 58·44	.....	.....
M	, , , ,	6 40 14·14	.....	.....
N	, , , ,	6 40 30·64	.....	.....
O	, , , ,	6 41 52·00	.....	.....
63 Aurigæ	Gr. Obs. 1836	7 0 17·83	Gr. Obs. 1836	50 25 7·98
64 Aurigæ	.....	.....	{Pond's Cat. 1112 Stars .....}	48 49 54·75
P	Gr. Obs. 1836	7 9 19·79	Gr. Obs. 1836	44 28 32·67
Q	Gr. Obs. 1837	7 16 3·31	Gr. Obs. 1837	41 36 59·16
R	Gr. Obs. 1836	7 16 27·48	Gr. Obs. 1836	41 45 5·84
S (Piaz. vii. 92)	, , , ,	7 16 32·71	Gr. Obs. 1837	41 29 22·06
T	, , , ,	7 22 19·89	Gr. Obs. 1836	41 27 45·24
U	, , , ,	7 26 4·99	Gr. Obs. 1837	41 53 2·38
W	, , , ,	7 28 59·65	Gr. Obs. 1836	41 29 31·61
Piazzi, viii. 15..	, , , ,	8 5 30·97	, , , ,	35 21 18·45
X	, , , ,	8 5 39·64	, , , ,	34 56 5·36
Y	, , , ,	8 38 35·92	, , , ,	31 52 3·72
Z	, , , ,	10 44 22·89	, , , ,	26 10 27·58

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Catalogue of the Mean Places of the Stars, &c. (continued).

Reference in Cambridge Observations, 1835.	Authority for Right Ascension.	Mean Right Ascension, 1835, Jan. 1.	Authority for North Polar Distance.	Mean N.P.D. 1835, Jan. 1.
		h m s		° ′ ″
a	Gr. Obs. 1836	10 52 8·33	Gr. Obs. 1836	25 59 36·23
α Ursæ Majoris..	, , , ,	10 53 28·80	, , , ,	27 21 36·75
b	Gr. Obs. 1837	10 56 46·56	Gr. Obs. 1837	23 15 46·40
a'	Gr. Obs. 1836	11 9 12·89	.....	.....
c	Gr. Obs. 1836	11 17 15·85	Gr. Obs. 1836	25 58 34·53
β Ursæ Majoris..	, , , ,	12 7 13·59	.....	.....
b'	, , , ,	12 35 48·17	.....	.....
d'	, , , ,	12 41 19·06	.....	.....
c^2 Scorpii	, , , ,	16 2 9·25	Gr. Obs. 1836	117 29 27·55
d	, , , ,	16 26 41·26	, , , ,	70 38 31·86
e	, , , ,	16 28 10·43	, , , ,	70 41 54·46
g	, , , ,	16 36 57·90	, , , ,	76 4 18·37
h	, , , ,	16 39 50·29	, , , ,	76 2 5·82
i	, , , ,	16 40 32·73	, , , ,	76 6 39·69
ι Ophiuchi	, , , ,	16 46 12·42	, , , ,	79 33 26·01
k	, , , ,	16 58 51·54	, , , ,	85 24 39·66
l	, , , ,	17 0 12·02	, , , ,	85 20 42·61
m	, , , ,	17 1 22·26	.....	.....
n	, , , ,	17 0 43·62	Gr. Obs. 1836	85 19 53·91
ν Ophiuchi	, , , ,	17 0 55·33	First Camb. Cat.	105 30 45·70
o	, , , ,	17 3 20·00	Gr. Obs. 1836	89 29 48·69
p	, , , ,	17 4 3·00	, , , ,	87 40 9·40
q	, , , ,	17 4 28·87	, , , ,	89 26 26·95
r	, , , ,	17 6 12·82	, , , ,	91 5 57·23
s	, , , ,	17 7 14·19	.....	.....
t	, , , ,	17 7 55·80	Gr. Obs. 1836	87 37 20·26
u	, , , ,	17 10 8·02	, , , ,	91 19 49·41
v	, , , ,	17 11 8·20	, , , ,	93 52 15·63
ρ Serpentis.....	, , , ,	17 11 33·17	, , , ,	102 40 15·94
w	, , , ,	17 14 10·41	, , , ,	96 56 15·61
Piazzi, xvii. 79 ..	, , , ,	17 14 55·70	, , , ,	99 11 47·18
x	, , , ,	17 15 28·89	, , , ,	95 9 54·68
A.S.C. 1998 ...	, , , ,	17 17 52·82	, , , ,	94 56 2·28

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K and L have not been found; K is probably the same star as J. The identity of *b*, as observed in right ascension, seems extremely doubtful; *c'* has not been observed; *f* and *i*, as remarked in the Cambridge Observations, are the same star. The right ascension of *m* may possibly be erroneous 1^m. G and I could not be observed with the transit.

c^2 *Scorpii* was compared with the comet in 1836, and it is therefore convenient to give its place for 1836, January 1. It is as follows: Æ $16^h\ 2^m\ 12^s{\cdot}92$; N.P.D. $117^\circ\ 29'\ 37''{\cdot}43$.

The apparent right ascensions used in the following sections are formed from these mean right ascensions by applying the corrections $Aa + Bb + Cc + Dd$, or A . cos Æ . cosec N.P.D. × (No. log = 8·8239) + B . sin Æ . cosec N.P.D. × (No. log = 8·8239) + C . sin Æ . cotan N.P.D. × (No. log = 0·1259) + C × (No. log = 0·4869) + D . cos Æ . cotan N.P.D. × (No. log = 8·8239). Log A, B, C, D, are taken from the *Nautical Almanac;* log *a, b, c, d*, from the Astronomical Society's Catalogue.

The apparent north polar distances are formed from these mean north polar distances by applying, with changed sign, the correction $Aa' + Bb' + Cc' + Dd'$, or A . sin N.P.D. × (No. log = 9·6375) − A . sin Æ . cos N.P.D. + B × cos Æ . cos N.P.D. + C . cos Æ × (No. log = 1·3020) − D . sin Æ. Log *a', b', c', d'*, are taken from the Astronomical Society's Catalogue.

The corrections of *α Ursæ Majoris* were taken from the *Nautical Almanac.*

Section II.

Computations of the Error of the Ephemeris of the Comet in Right Ascension, from Differential Observations only.

K is assumed to be the same star as J, and *f* the same star as *i*, with an error of 5^m. In series 157, the time for Piazzi, VIII. 15, appears to be 1^m too great; it is diminished here by 1^m. In the series 212–218, the correction of refraction indicated in the Errata to the Cambridge Observations, 1835, is taken into account. In series 229, the time of transit of *m* is increased 1^m.

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Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Comet follows Star by	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.			h m s	m s	h m s	h m s	s
Sept. 2	100	A	6 9 0·06	−17 34·49	5 51 25·57	5 52 8·86	+43·29
	101	2 Geminorum	5 56 46·07	− 4 37·95	5 52 8·12	5 52 9·59	+ 1·47
	102	139 Tauri ..	5 47 56·57	+ 4 21·81	5 52 8·38	5 52 10·18	+ 1·80
		2 Geminorum	5 56 46·07	− 4 37·37	5 52 8·70	5 52 10·18	+ 1·48
	103	2 Geminorum	5 56 46·07	− 4 29·06	5 52 17·01	5 52 11·31	− 5·70
20	104	B	6 11 31·47	+ 58·05	6 12 29·52	6 12 32·09	+ 2·57
	105	B	6 11 31·47	+ 1 1·31	6 12 32·78	6 12 32·68	− 0·10
	106	B	6 11 31·47	+ 1 0·56	6 12 32·03	6 12 32·96	+ 0·93
	107	B	6 11 31·47	+ 1 1·56	6 12 33·03	6 12 33·22	+ 0·19
	108	B	6 11 31·47	+ 1 3·31	6 12 34·78	6 12 33·50	− 1·28
	113	B	6 11 31·47	+ 1 3·79	6 12 35·26	6 12 36·52	+ 1·26
	114	B	6 11 31·47	+ 1 3·29	6 12 34·76	6 12 37·02	+ 2·26
25	118	E	6 21 41·95	+ 40·92	6 22 22·87	6 22 25·14	+ 2·27
		F	6 22 54·64	− 33·08	6 22 21·56	6 22 25·14	+ 3·58
	119	E	6 21 41·95	+ 44·66	6 22 26·61	6 22 25·86	− 0·75
		F	6 22 54·64	− 29·84	6 22 24·80	6 22 25·86	+ 1·06
	124	E	6 21 41·95	+ 49·37	6 22 31·32	6 22 31·01	− 0·31
		F	6 22 54·64	− 24·13	6 22 30·51	6 22 31·01	+ 0·50
	125	C	6 19 23·64	+ 2 57·47	6 22 21·11	6 22 31·74	+10·63
		D	6 19 51·56	+ 2 42·70	6 22 34·26	6 22 31·74	− 2·52
		E	6 21 41·95	+ 53·37	6 22 35·32	6 22 31·74	− 3·58
		F	6 22 54·64	− 21·13	6 22 33·51	6 22 31·74	− 1·77
	127	F	6 22 54·64	− 21·86	6 22 32·78	6 22 33·07	+ 0·29
27	129	H	6 26 24·66	+ 1 30·64	6 27 55·30	6 27 54·95	− 0·35
		J	6 27 0·14	+ 41·14	6 27 41·28	6 27 54·95	+13·67
	131	J	6 27 0·14	+ 41·52	6 27 41·66	6 27 58 39	+16·73
30	133	M	6 40 15·93	− 40·43	6 39 35·50	6 39 36·79	+ 1·29
		N	6 40 32·43	− 55·43	6 39 37·00	6 39 36·79	− 0·21
		O	6 41 53·78	− 2 9·43	6 39 44·35	6 39 36·79	− 7·56
Oct. 2	140	63 Aurigæ ..	7 0 19·60	− 8 36·87	6 51 42·73	6 51 45·92	+ 3·19
4	144	P	7 9 21·68	− 1·34	7 9 20·34	7 9 19·88	− 0·46
	145	P	7 9 21·68	+ 10·01	7 9 31·69	7 9 32·57	+ 0·88
5	148	U	7 26 6·85	− 3 6·49	7 23 0·36	7 23 0·85	+ 0·49
	149	Q	7 16 5·25	+ 7 12·37	7 23 17·62	7 23 16·47	− 1·15
		R	7 16 29·42	+ 6 48·87	7 23 18·29	7 23 16·47	− 1·82
		S	7 16 34·65	+ 6 42·37	7 23 17·02	7 23 16·47	− 0·55

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Computations of the Error, &c. from Differential Observations only (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Comet follows Star by	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.			h m s	m s	h m s	h m s	s
Oct. 5	150	R	7 16 29·42	+ 7 4·44	7 23 33·86	7 23 32·78	− 1·08
		S	7 16 34·65	+ 6 57·44	7 23 32·09	7 23 32·78	+ 0·69
	151	T	7 22 21·79	+ 1 15·75	7 23 37·54	7 23 38·56	+ 1·02
		U	7 26 6·85	− 2 25·43	7 23 41·42	7 23 38·56	− 2·86
		W	7 29 1·49	− 5 23·21	7 23 38·28	7 23 38·56	+ 0·28
7	153	Piazzi, viii. 15	8 5 32·73	− 11·57	8 5 21·16	8 5 17·20	− 3·96
	154	Piazzi, viii. 15	8 5 32·73	− 1·88	8 5 30·85	8 5 29·91	− 0·94
	156	Piazzi, viii. 15	8 5 32·73	+ 1 36·44	8 7 9·17	8 7 6·19	− 2·98
		X	8 5 41·42	+ 1 25·57	8 7 6·99	8 7 6·19	− 0·80
	157	Piazzi, viii. 15	8 5 32·73	+ 1 41·13	8 7 13·86	8 7 16·93	+ 3·07
	158	X	8 5 41·42	+ 2 28·05	8 8 9·47	8 8 10·45	+ 0·98
8	160	Y	8 38 37·48	+ 1 23·84	8 40 1·32	8 40 0·32	− 1·00
	161	Y	8 38 37·48	+ 1 46·75	8 40 24·23	8 40 22·06	− 2·17
	162	Y	8 38 37·48	+ 2 6·28	8 40 43·76	8 40 41·31	− 2·45
10	165	Z	10 44 23·09	+ 2 20·40	10 46 43·49	10 46 38·74	− 4·75
	166	*b*	10 56 46·45	− 4 59·18	10 51 47·27	10 51 59·87	+12·60
	167	*a*	10 52 8·43	+ 32·31	10 52 40·74	10 52 39·58	− 1·16
	168	α Ursæ Majoris	10 53 28·95	− 13·27	10 53 15·68	10 53 11·86	− 3·84
	169	α Ursæ Majoris	10 53 28·95	+ 18·85	10 53 47·80	10 53 44·89	− 2·91
	171	α Ursæ Majoris	10 53 28·95	+ 2 39·51	10 56 8·46	10 56 5·39	− 3·07
	172	α Ursæ Majoris	10 53 28·95	+ 3 29·70	10 56 58·65	10 56 57·56	− 1·09
	174	*c*	11 17 15·66	+ 1 2·17	11 18 17·83	11 18 15·00	− 2·83
17	178	*e*	16 28 10·72	− 37·29	16 27 33·45	16 27 32·64	− 0·79
	179	*e*	16 28 10·72	− 34·44	16 27 36·28	16 27 35·04	− 1·24
	180	*d*	16 26 41·56	+ 57·85	16 27 39·41	16 27 37·32	− 2·09
		e	16 28 10·72	− 31·68	16 27 39·04	16 27 37·32	− 1·72
	181	*e*	16 28 10·72	− 30·22	16 27 40·50	16 27 39·49	− 1·01
18	188	*g*	16 36 58·29	+ 1 24·72	16 38 23·01	16 38 22·76	− 0·25
		h	16 39 50·69	− 1 28·39	16 38 22·30	16 38 22·76	+ 0·46
		i	16 40 33·14	− 2 10·15	16 38 22·99	16 38 22·76	− 0·23
	189	*g*	16 36 58·29	+ 1 26·78	16 38 25·07	16 38 25·07	0·00
		h	16 39 50·69	− 1 26·19	16 38 24·50	16 38 25·07	+ 0·57
		i	16 40 33·14	− 2 8·01	16 38 25·13	16 38 25·07	− 0·06
	190	*g*	16 36 58·29	+ 1 30·30	16 38 28·59	16 38 28·19	− 0·40
		i	16 40 33·14	− 2 5·06	16 38 28·08	16 38 28·19	+ 0·11

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Computations of the Error, &c. from Differential Observations only (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Comet follows Star by	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.			h m s	m s	h m s	h m s	s
Oct. 18	191	*g*	16 36 58·29	+1 32·80	16 38 31·09	16 38 30·82	−0·27
		i	16 40 33·14	−2 2·35	16 38 30·79	16 38 30·82	+0·03
	192	*i*	16 40 33·14	−1 56·60	16 38 36·54	16 38 36·99	+0·45
	193	*i*	16 40 33·14	−1 47·10	16 38 46·04	16 38 47·02	+0·98
19	197	*s* Ophiuchi..	16 46 12·88	− 44·34	16 45 28·54	16 45 27·01	−1·53
	198	*s* Ophiuchi..	16 46 12·88	− 43·02	16 45 29·86	16 45 28·12	−1·74
	203	*s* Ophiuchi..	16 46 12·88	− 39·90	16 45 32·98	16 45 31·81	−1·17
	204	*s* Ophiuchi..	16 46 12·88	− 38·80	16 45 34·08	16 45 32·81	−1·27
	205	*s* Ophiuchi..	16 46 12·88	− 37·37	16 45 35·51	16 45 33·66	−1·85
	207	*s* Ophiuchi..	16 46 12·88	− 36·26	16 45 36·62	16 45 34·83	−1·79
	209	*s* Ophiuchi..	16 46 12·88	− 35·18	16 45 37·70	16 45 35·91	−1·79
	210	*s* Ophiuchi..	16 46 12·88	− 34·83	16 45 38·05	16 45 36·71	−1·34
	211	*s* Ophiuchi..	16 46 12·88	− 34·32	16 45 38·56	16 45 37·65	−0·91
	212	*s* Ophiuchi..	16 46 12·88	− 12·55	16 46 0·33	16 46 3·09	+2·76
	213	*s* Ophiuchi..	16 46 12·88	− 9·55	16 46 3·33	16 46 4·87	+1·54
	214	*s* Ophiuchi..	16 46 12·88	− 6·13	16 46 6·75	16 46 5·71	−1·04
	215	*s* Ophiuchi..	16 46 12·88	− 5·64	16 46 7·24	16 46 6·13	−1·11
	216	*s* Ophiuchi..	16 46 12·88	− 3·63	16 46 9·25	16 46 6·40	−2·85
	217	*s* Ophiuchi..	16 46 12·88	− 5·59	16 46 7·29	16 46 6·76	−0·53
	218	*s* Ophiuchi..	16 46 12·88	− 7·54	16 46 5·34	16 46 7·11	+1·77
21	223	*l*	17 0 12·57	−3 35·12	16 56 37·45	16 56 36·98	−0·47
	224	*n*	17 0 44·17	−4 4·20	16 56 39·97	16 56 38·55	−1·42
	225	*l*	17 0 12·57	−3 32·53	16 56 40·04	16 56 39·70	−0·34
	226	*k*	16 58 52·09	−2 10·41	16 56 41·68	16 56 40·65	−1·03
		l	17 0 12·57	−3 31·01	16 56 41·56	16 56 40·65	−0·91
	227	*l*	17 0 12·57	−3 30·24	16 56 42·33	16 56 41·66	−0·67
	228	*l*	17 0 12·57	−3 29·10	16 56 43·47	16 56 42·93	−0·54
	229	*m*	17 1 22·81	−4 21·51	16 57 1·30	16 56 58·95	−2·35
22	235	*t*	17 7 56·38	−7 18·31	17 0 38·07	17 0 37·76	−0·31
	236	*p*	17 4 3·57	−3 23·74	17 0 39·83	17 0 39·82	−0·01
		t	17 7 56·38	−7 16·78	17 0 39·60	17 0 39·82	+0·22
	237	*p*	17 4 3·57	−3 21·48	17 0 42·09	17 0 41·77	−0·32
		t	17 7 56·38	−7 14·48	17 0 41·90	17 0 41·77	−0·13

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Computations of the Error, &c. from Differential Observations only (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Comet follows Star by	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.			h m s	m s	h m s	h m s	s
Oct. 23	238	*o*	17 3 20·58	+ 38·04	17 3 58·62	17 3 57·64	−0·98
		q	17 4 29·45	− 31·79	17 3 57·66	17 3 57·64	−0·02
	239	*q*	17 4 29·45	− 31·25	17 3 58·20	17 3 58·10	−0·10
	241	*q*	17 4 29·45	− 30·67	17 3 58·78	17 3 58·78	0·00
	242	*q*	17 4 29·45	− 30·70	17 3 58·75	17 3 59·07	+0·32
24	246	*r*	17 6 13·42	+ 27·51	17 6 40·93	17 6 42·47	+1·54
		s	17 7 14·80	− 32·27	17 6 42·53	17 6 42·47	−0·06
	247	*u*	17 10 8·65	−3 24·65	17 6 44·00	17 6 43·18	−0·82
	248	*u*	17 10 8·65	−3 24·64	17 6 44·01	17 6 43·77	−0·24
	249	*u*	17 10 8·65	−3 23·88	17 6 44·77	17 6 44·35	−0·42
	250	*u*	17 10 8·65	−3 22·71	17 6 45·94	17 6 45·01	−0·93
	251	*u*	17 10 8·65	−3 20·75	17 6 47·90	17 6 46·94	−0·96
26	252	A.S.C. 1998	17 17 53·48	−7 13·93	17 10 39·55	17 10 39·75	+0·20
	253	*v*	17 11 8·83	− 27·03	17 10 41·80	17 10 41·54	−0·26
		A.S.C. 1998	17 17 53·48	−7 11·91	17 10 41·57	17 10 41·54	−0·03
	254	*v*	17 11 8·83	− 26·23	17 10 42·60	17 10 42·32	−0·28
	255	A.S.C. 1998	17 17 53·48	−7 10·46	17 10 43·02	17 10 43·58	+0·56
27	257	A.S.C. 1998	17 17 53·48	−5 43·34	17 12 10·14	17 12 9·61	−0·53
	258	A.S.C. 1998	17 17 53·48	−5 43·28	17 12 10·20	17 12 10·05	−0·15
	259	A.S.C. 1998	17 17 53·48	−5 42·27	17 12 11·21	17 12 10·52	−0·69
	260	*x*	17 15 29·54	−3 18·66	17 12 10·88	17 12 10·97	+0·09
		A.S.C. 1998	17 17 53·48	−5 43·14	17 12 10·34	17 12 10·97	+0·63
	261	*x*	17 15 29·54	−3 17·17	17 12 12·37	17 12 11·62	−0·75
		A.S.C. 1998	17 17 53·48	−5 41·23	17 12 12·25	17 12 11·62	−0·63
	262	*x*	17 15 29·54	−3 16·86	17 12 12·68	17 12 12·05	−0·63
		A.S.C. 1998	17 17 53·48	−5 41·18	17 12 12·30	17 12 12·05	−0·25
29	264	*w*	17 14 11·06	+ 10·29	17 14 21·35	17 14 21·04	−0·31
	265	*w*	17 14 11·06	+ 10·66	17 14 21·72	17 14 21·20	−0·52
	266	*w*	17 14 11·06	+ 11·00	17 14 22·06	17 14 21·30	−0·76
	267	*w*	17 14 11·06	+ 11·27	17 14 22·33	17 14 21·40	−0·93
	268	*w*	17 14 11·06	+ 11·35	17 14 22·41	17 14 21·49	−0·92
	269	*w*	17 14 11·06	+ 11·23	17 14 22·29	17 14 21·62	−0·67
	270	*w*	17 14 11·06	+ 11·22	17 14 22·28	17 14 21·73	−0·55
	271	*w*	17 14 11·06	+ 11·60	17 14 22·66	17 14 21·83	−0·83

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Computations of the Error, &c. from Differential Observations only (concluded).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Comet follows Star by	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.			h m s	m s	h m s	h m s	s
Oct. 29	272	*w*	17 14 11·06	+ 11·45	17 14 22·51	17 14 22·17	−0·34
	273	*w*	17 14 11·06	+ 11·62	17 14 22·68	17 14 22·27	−0·41
Nov. 1	276	Piazzi, xvii. 79	17 14 56·34	+1 6·82	17 16 3·16	17 16 2·95	−0·21
	277	Piazzi, xvii. 79	17 14 56·34	+1 6·61	17 16 2·95	17 16 3·08	+0·13
8	281	ρ Serpentis	17 11 33·79	+3 26·78	17 15 0·57	17 15 0·24	−0·33
	282	ρ Serpentis	17 11 33·79	+3 25·99	17 14 59·78	17 15 0·12	+0·34
	283	ρ Serpentis	17 11 33·79	+3 26·57	17 15 0·36	17 14 59·98	−0·38
	284	ρ Serpentis	17 11 33·79	+3 26·16	17 14 59·95	17 14 59·87	−0·08
	285	ρ Serpentis	17 11 33·79	+3 26·16	17 14 59·95	17 14 59·76	−0·19
	286	ρ Serpentis	17 11 33·79	+3 24·66	17 14 58·45	17 14 59·65	+1·20
15	294	ρ Serpentis	17 11 33·78	−2 3·20	17 9 30·58	17 9 29·91	−0·67
	295	ρ Serpentis	17 11 33·78	−2 3·67	17 9 30·11	17 9 29·66	−0·45
	296	ρ Serpentis	17 11 33·78	−2 3·90	17 9 29·88	17 9 29·38	−0·50
	297	ρ Serpentis	17 11 33·78	−2 4·28	17 9 29·50	17 9 29·14	−0·36
	298	η Ophiuchi	17 0 55·93	+8 32·05	17 9 27·98	17 9 28·42	+0·44
		ρ Serpentis	17 11 33·78	−2 6·01	17 9 27·77	17 9 28·42	+0·65
18	302	η Ophiuchi	17 0 55·94	+5 22·31	17 6 18·25	17 6 18·13	−0·12
	303	η Ophiuchi	17 0 55·94	+5 22·11	17 6 18·05	17 6 17·73	−0·32
	304	η Ophiuchi	17 0 55·94	+5 21·17	17 6 17·11	17 6 17·30	+0·19
	305	η Ophiuchi	17 0 55·94	+5 20·28	17 6 16·22	17 6 16·91	+0·69
1836.							
Jan. 16	308	c^2 Scorpii ..	16 2 11·13	−4 1·48	15 58 9·65	15 58 16·14	+6·49
	309	c^2 Scorpii ..	16 2 11·13	−3 58·51	15 58 12·62	15 58 15·35	+2·73
	310	c^2 Scorpii ..	16 2 11·13	−4 1·70	15 58 9·43	15 58 14·66	+5·23

NOTES.

Series 100, 101, 102, 103, comprise the observations of September 2, when no light could be allowed near the instrument. They are too uncertain to be used for any correction of the comet's orbit.

Series 125. There is no doubt that the observation with C is erroneous, or that the star has not been identified; the index error which it gives is irreconcileable with those given by the other stars.

Series 129 and 131 are very difficult to explain. The error of ephemeris given by H agrees well with the general series of errors, and those given by J are discordant; yet the index errors

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of the instrument given by J appear much better than that given by H. The single observation of J made at Greenwich is liable to great doubt (see Greenwich Observations, 1837, transits, March 7).

Series 133. The index error given by O does not agree well with the others.

Series 166. The index error given by *b* is discordant to the same amount, or nearly so, as the discordance in the errors of ephemeris; the discordance, therefore, does not arise from bad observation of the comet, but from bad observation of the star, or from mistake in attempting to identify it.

The other discordances, probably, are not greater than are inevitable in the observation of a body so ill-defined as this comet.

Section III.

Computation of the Index Errors in Right Ascension of the Equatoreal.

The index errors were computed for the following purposes, which are essentially different. One was to shew, by the general agreement or disagreement of the errors deduced from different small stars, the confidence which the observation of each star, or the attempted identification of the star, probably deserves. A second purpose was to shew the correctness of position and general steadiness of the instrument, by the observations of stars on whose place and accuracy of observation there was no reasonable doubt. A third purpose was, to supply the means of computing the place of the comet for those series in which no star was observed, or in which the observation, &c. of the star appears erroneous. For the first purpose, the correction for refraction was not necessary; but it was indispensable for the second and third.

The requisite numbers have been taken from the Cambridge Observations without alteration, except in the observation of *Pollux*, series 159, where it appears probable that the wires observed were the III. IV. and V. instead of the II. III. and IV. as entered in the Observations; the transit, &c. have in consequence been diminished by $10^s.65$.

The following refractions in right ascension have been introduced into the present calculations:—

Series 167,	*a*	$-3^s.90$
168,	*α* Ursæ Majoris	$-3^s.54$
169,	*α* Ursæ Majoris	$-3^s.16$

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Series 171,	α Ursæ Majoris		s −1·47
172,	α Ursæ Majoris		−0·79
178,	*e*		−2·82
179,	*e*		−2·89
180,	*d*		−3·01
180,	*e*		−3·01
181,	*e*		−3·09
235,	*t*		−3·10

The clock errors have been deduced from the comparisons in page 139 of the Observations.

The apparent right ascensions of the principal stars are taken from the *Nautical Almanac*.

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Observed Right Ascension affected with Clock Error and Index Error, and sometimes with Refraction.	Clock Error and Index Error, &c.	Computed Clock Error.	Index Error affected with Refraction.	Index Error free from Refraction.	Adopted Index Correction.
1835.			h m s	h m s	s	s	s	s	s
Sept. 20	113	B	6 11 31·47	6 11 12·22	−19·25	−7·75	−11·50		
	114	B	6 11 31·47	6 11 12·67	−18·80	−7·74	−11·06		
	115	β Aquarii ..	21 22 54·45	21 22 42·88	−11·57	−7·86	....	−3·71	+3·69
	116	48 Aurigæ ..	6 17 59·03	6 17 48·07	−10·96	−7·70	....	−3·26	
	117	α Andromedæ	23 59 54·91	23 59 43·05	−11·86	−7·69	....	−4·17	
25	118	E	6 21 41·95	6 21 26·67	−15·28	−2·57	−12·71		
		F	6 22 54·64	6 22 40·67	−13·97	−2·57	−11·40		
	119	E	6 21 41·95	6 21 24·02	−17·93	−2·57	−15·36		
		F	6 22 54·64	6 22 38·52	−16·12	−2·57	−13·55		
	124	E	6 21 41·95	6 21 26·77	−15·18	−2·58	−12·60		
		F	6 22 54·64	6 22 40·27	−14·37	−2·58	−11·79		
	125	C	6 19 23·64	6 19 21·77	− 1·87	−2·58	+ 0·71		
		D	6 19 51·56	6 19 36·54	−15·02	−2·58	−12·44		
		E	6 21 41·95	6 21 25·87	−16·08	−2·58	−13·50		
		F	6 22 54·64	6 22 40·37	−14·27	−2·58	−11·69		
	126	A.S.C. 808	6 21 42·77	6 21 35·46	− 7·31	−2·59	....	−4·72	
	127	F	6 22 54·64	6 22 46·93	− 7·71	−2·59	....	−5·12	
	128	Capella ..	5 4 32·96	5 4 29·25	− 3·71	−2·59	....	−1·12	
27	129	H	6 26 24·66	6 26 2·22	−22·44	−2·67	−29·77		
		J	6 27 0·14	6 26 51·72	− 8·42	−2·67	− 5·75		
	131	J	6 27 0·14	6 26 59·28	− 0·86	−2·65	+ 1·79		
	132	α Andromedæ	23 59 54·96	23 59 44·54	−10·42	−2·62	....	−7·80	

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Computation of the Index Errors in Right Ascension of the Equatoreal (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Observed Right Ascension affected with Clock Error and Index Error, and sometimes with Refraction.	Clock Error and Index Error, &c.	Computed Clock Error.	Index Error affected with Refraction.	Index Error free from Refraction.	Adopted Index Correction.
1835.			h m s	h m s	s	s	s	s	s
Sept. 30	133	M	6 40 15·93	6 40 2·07	−13·86	−4·47	− 9·39		
		N	6 40 32·43	6 40 17·07	−15·36	−4·47	−10·87		
		O	6 41 53·78	6 41 31·07	−22·71	−4·47	−18·24		
Oct. 2	140	63 Aurigæ ..	7 0 19·60	7 0 12·79	− 6·81	−2·44	....	−4·37	+4·33
	141	Castor ..	7 24 5·30	7 23 58·04	− 7·26	−2·44	....	−4·82	
	142	Pollux ..	7 35 14·01	7 35 7·76	− 6·25	−2·44	....	−3·81	
4	145	P	7 9 21·68	7 9 12·20	− 9·48	−0·21	− 9·27		
	147	Capella ..	5 4 33·32	5 4 31·12	− 2·20	−0·20	....	−2·00	
5	148	U	7 26 6·85	7 25 57·70	− 9·15	+0·37	− 9·52		
	149	Q	7 16 5·25	7 15 56·35	− 8·90	+0·38	− 9·28		
		R	7 16 29·42	7 16 19·85	− 9·57	+0·38	− 9·95		
		S	7 16 34·65	7 16 26·35	− 8·30	+0·38	− 8·68		
	150	R	7 16 29·42	7 16 20·85	− 8·57	+0·39	− 8·96		
		S	7 16 34·65	7 16 27·85	− 6·80	+0·39	− 7·19		
	151	T	7 22 21·79	7 22 15·81	− 5·98	+0·39	− 6·37		
		U	7 26 6·85	7 25 56·99	− 9·86	+0·39	−10·25		
		W	7 29 1·49	7 28 54·77	− 6·72	+0·39	− 7·11		
	152	Castor ..	7 24 5·40	7 24 1·31	− 4·09	+0·40	....	−4·49	
7	153	Piazzi, viii. 15	8 5 32·73	8 5 25·18	− 7·55	+1·47	− 9·02		
	155	Piazzi, viii. 15	8 5 32·73	8 5 31·06	− 1·67	+1·48	....	−3·15	
	156	Piazzi, viii. 15	8 5 32·73	8 5 26·53	− 6·20	+1·50	− 7·70		
		X	8 5 41·41	8 5 37·40	− 4·01	+1·50	− 5·51		
	157	Piazzi, viii. 15	8 5 32·73	8 5 33·27	+ 0·54	+1·50	− 0·96		
	158	X	8 5 41·41	8 5 38·86	− 2·55	+1·52	− 4·07		
	159	Pollux ..	7 35 14·20	7 35 14·56	+ 0·36	+1·52	....	−1·16	
8	160	Y	8 38 37·48	8 38 37·01	− 0·47	+1·99	− 2·46		
	161	Y	8 38 37·48	8 38 35·18	− 2·30	+2·00	− 4·30		
	162	Y	8 38 37·48	8 38 34·58	− 2·90	+2·00	− 4·90		
	163	Capella ..	5 4 33·48	5 4 35·12	+ 1·64	+2·01	....	−0·37	
	164	β Tauri	5 15 54·40	5 15 54·77	+ 0·37	+2·02	....	−1·65	
10	165	Z	10 44 23·09	10 44 5·98	−17·11	+3·40	−20·51		
	166	*b*	10 56 46·45	10 57 8·80	+22·35	+3·40	+18·95		−2·84
	167	*a*	10 52 8·43	10 52 19·50	+11·07	+3·40	+ 7·67	+3·77	

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Computation of the Index Errors in Right Ascension of the Equatoreal (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Observed Right Ascension affected with Clock Error and Index Error, and sometimes with Refraction.	Clock Error and Index Error, &c.	Computed Clock Error.	Index Error affected with Refraction.	Index Error free from Refraction.	Adopted Index Correction.
1835.			h m s	h m s	s	s	s	s	s
Oct. 10	168	α Ursæ Majoris	10 53 28·95	10 53 37·76	+ 8·81	+3·40	+5·41	+1·87	−2·84
	169	α Ursæ Majoris	10 53 28·95	10 53 38·99	+10·04	+3·40	+6·64	+3·48	
	171	α Ursæ Majoris	10 53 28·95	10 53 37·51	+ 8·56	+3·40	+5·16	+3·69	
	172	α Ursæ Majoris	10 53 28·95	10 53 37·99	+ 9·04	+3·40	+5·64	+4·85	
	174	*c*	11 17 15·66	11 17 18·50	+ 2·84	+3·41	....	−0·57	
									+7·12
17	178	*e*	16 28 10·72	16 28 10·53	− 0·19	+3·92	−4·11	−6·93	
	179	*e*	16 28 10·72	16 28 10·35	− 0·37	+3·92	−4·29	−7·18	
	180	*d*	16 26 41·56	16 26 41·05	− 0·51	+3·90	−4·41	−7·42	
		e	16 28 10·72	16 28 10·58	− 0·14	+3·90	−4·04	−7·05	
	181	*e*	16 28 10·72	16 28 10·78	+ 0·06	+3·90	−3·84	−6·93	
	184	α Lyræ ..	18 31 21·53	18 31 18·22	− 3·31	+3·83	....	−7·14	
									+4·73
18	188	*g*	16 36 58·29	16 36 59·95	+ 1·66	+0·28	+1·38		
		h	16 39 50·69	16 39 53·06	+ 2·37	+0·28	+2·09		
		i	16 40 33·14	16 40 34·82	+ 1·68	+0·28	+1·40		
	189	*g*	16 36 58·29	16 37 0·65	+ 1·36	+0·27	+1·09		
		h	16 39 50·69	16 39 53·62	+ 2·93	+0·27	+2·66		
		i	16 40 33·14	16 40 35·44	+ 2·30	+0·27	+2·03		
	190	*g*	16 36 58·29	16 37 1·22	+ 2·93	+0·27	+2·86		
		i	16 40 33·14	16 40 36·58	+ 3·44	+0·27	+3·17		
	191	*g*	16 36 58·29	16 36 59·51	+ 1·22	+0·26	+0·96		
		i	16 40 33·14	16 40 34·66	+ 1·52	+0·26	+1·26		
	192	*i*	16 40 33·14	16 40 37·52	+ 4·38	+0·26	+4·13		
	193	*i*	16 40 33·14	16 40 42·30	+ 9·16	+0·22	+8·94		
	194	α Aquilæ ..	19 42 45·36	19 42 41·61	− 3·75	+0·21	....	−3·96	
	195	β Aquilæ ..	19 47 13·96	19 47 8·26	− 5·70	+0·21	....	−5·91	
	196	α Aquilæ ..	19 42 45·36	19 42 41·26	− 4·10	+0·21	....	−4·31	
19	197	ι Ophiuchi.	16 46 12·88	16 46 7·15	− 5·73	−1·49	−4·24		
	198	ι Ophiuchi.	16 46 12·88	16 46 6·60	− 6·28	−1·49	−4·79		
	203	ι Ophiuchi.	16 46 12·88	16 46 6·87	− 6·01	−1·50	−4·51		
	204	ι Ophiuchi.	16 46 12·88	16 46 7·15	− 5·73	−1·50	−4·23		
	210	ι Ophiuchi.	16 46 12·88	16 46 7·50	− 5·38	−1·54	−3·84		
	211	ι Ophiuchi.	16 46 12·88	16 46 7·22	− 5·66	−1·56	−4·10		
	212	ι Ophiuchi.	16 46 12·88	16 46 8·99	− 3·89	−1·58	....	−2·31	

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Computation of the Index Errors in Right Ascension of the Equatoreal (*continued*).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Observed Right Ascension affected with Clock Error and Index Error, and sometimes with Refraction.	Clock Error and Index Error, &c.	Computed Clock Error.	Index Error affected with Refraction.	Index Error free from Refraction.	Adopted Index Correction.
1835.			h m s	h m s	s	s	s	s	s
Oct. 19	213	ι Ophiuchi..	16 46 12·88	16 46 9·17	— 3·71	—1·58	....	—2·13	
	218	ι Ophiuchi..	16 46 12·88	16 46 11·04	— 1·84	—1·64	....	—0·20	
	219	Pollux ...	7 35 14·60	7 35 9·12	— 5·48	—1·82	....	—3·66	+4·58
21	220	α Aquilæ...	19 42 45·31	19 42 37·98	— 7·33	—2·76	....	—4·57	
	223	*l*	17 0 12·57	17 0 8·25	— 4·32	—2·77	—1·55		
	224	*n*	17 0 44·17	17 0 38·90	— 5·27	—2·78	—2·49		
	225	*l*	17 0 12·57	17 0 4·94	— 7·63	—2·80	—4·83		
	226	*k*	16 58 52·09	16 58 45·50	— 6·59	—2·80	—3·79		
		l	17 0 12·57	17 0 6·10	— 6·47	—2·82	—3·65		
	227	*l*	17 0 12·57	17 0 5·64	— 6·93	—2·84	—4·09		
	228	*l*	17 0 12·57	17 0 8·65	— 3·92	—2·86	—1·06		
	229	*m*	17 1 22·81	17 1 20·10	— 2·71	—3·02	+0·31		
	230	α Aquilæ...	19 42 45·31	19 42 38·88	— 6·43	—3·07	....	—3·36	
	231	β Aquilæ...	19 47 13·91	19 47 4·92	— 8·99	—3·09	....	—5·90	
22	235	*t*	17 7 56·38	17 7 49·48	— 6·90	—4·79	—2·11	—5·39	
	236	*p*	17 4 3·57	17 3 57·04	— 6·53	—4·80	—1·73		
		t	17 7 56·38	17 7 50·08	— 6·30	—4·80	—1·50		
	237	*p*	17 4 3·57	17 3 55·55	— 8·02	—4·82	—3·20		
		t	17 7 56·38	17 7 48·55	— 7·83	—4·82	—3·01		
23	238	*o*	17 3 20·58	17 3 11·27	— 9·31	—7·62	—1·69		
		q	17 4 29·45	17 4 21·10	— 8·35	—7·62	—0·73		
	239	*q*	17 4 29·45	17 4 21·38	— 8·07	—7·62	—0·45		
	241	*q*	17 4 29·45	17 4 21·47	— 7·98	—7·63	—0·35		+5·06
	242	*q*	17 4 29·45	17 4 21·80	— 7·65	—7·63	—0·02		
	243	Regulus..	9 59 35·87	9 59 23·19	—12·68	—7·90	....	—4·78	
	244	Regulus..	9 59 35·87	9 59 22·76	—13·11	—7·91	....	—5·20	
24	246	*r*	17 6 13·42	17 6 0·99	—12·43	—8·10	....	—4·33	
		s	17 7 14·80	17 7 0·77	—14·03	—8·11	....	—5·92	
	247	*u*	17 10 8·65	17 10 0·38	— 8·27	—8·11	—0·16		
	248	*u*	17 10 8·65	17 10 1·03	— 7·62	—8·12	+0·50		
	249	*u*	17 10 8·65	17 10 1·39	— 7·26	—8·12	+0·86		
	250	*u*	17 10 8·65	17 10 1·30	— 7·35	—8·12	+0·77		

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Computation of the Index Errors in Right Ascension of the Equatoreal (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Observed Right Ascension affected with Clock Error and Index Error, and sometimes with Refraction.	Clock Error and Index Error, &c.	Computed Clock Error.	Index Error affected with Refraction.	Index Error free from Refraction.	Adopted Index Correction.
1835.			h m s	h m s	s	s	s	s	s
Oct. 24	251	*u*	17 10 8·65	17 10 5·35	− 3·30	− 8·13	+4·83		
26	252	A.S.C. 1998	17 17 53·48	17 17 35·07	−18·41	− 8·97	....	−9·44	
	253	*v*	17 11 8·83	17 10 50·62	−18·21	− 9·02	....	−9·19	
		A.S.C. 1998	17 17 53·48	17 17 35·50	−17·98	− 9·04	....	−8·94	
	254	*v*	17 11 8·83	17 10 50·08	−18·75	− 9·06	....	−9·69	
	255	A.S.C. 1998	17 17 53·48	17 17 35·84	−17·64	− 9·06	....	−8·58	
	256	α Aquilæ ..	19 42 45·23	19 42 31·15	−14·08	− 8·87	....	−5·21	
27	257	A.S.C. 1998	17 17 53·48	17 17 34·43	−19·05	−10·95	....	−8·10	
	258	A.S.C. 1998	17 17 53·48	17 17 36·65	−16·83	−10·94	....	−5·89	
	259	A.S.C. 1998	17 17 53·48	17 17 34·61	−18·87	−10·94	....	−7·93	
	260	*x*	17 15 29·54	17 15 10·66	−18·88	−10·94	....	−7·94	
		A.S.C. 1998	17 17 53·48	17 17 35·14	−18·34	−10·94	....	−7·40	
	261	*x*	17 15 29·54	17 15 10·71	−18·83	−10·93	....	−7·90	
		A.S.C. 1998	17 17 53·48	17 17 34·77	−18·71	−10·93	....	−7·78	
	262	*x*	17 15 29·54	17 15 10·23	−19·31	−10·93	....	−8·38	
		A.S.C. 1998	17 17 53·48	17 17 34·55	−18·93	−10·92	....	−8·01	
	263	α Aquilæ ..	19 42 45·22	19 42 26·10	−19·12	−10·92	....	−8·20	
29	264	*w*	17 14 11·06	17 13 55·82	−15·24	− 9·49	−5·75		
	265	*w*	17 14 11·06	17 13 58·50	−12·56	− 9·49	−3·07		
	266	*w*	17 14 11·06	17 13 56·86	−14·20	− 9·50	−4·70		
	267	*w*	17 14 11·06	17 13 55·93	−15·13	− 9·50	−5·63		
	268	*w*	17 14 11·06	17 13 56·20	−14·86	− 9·50	−5·36		
	269	*w*	17 14 11·06	17 13 56·69	−14·37	− 9·51	−4·86		
	270	*w*	17 14 11·06	17 13 56·81	−14·25	− 9·51	−4·74		
	271	*w*	17 14 11·06	17 13 56·80	−14·26	− 9·52	−4·74		
	272	*w*	17 14 11·06	17 13 57·97	−13·09	− 9·52	−3·57		
	274	α Aquilæ ..	19 42 45·18	19 42 25·51	−19·67	− 9·53	....	−10·14	+9·22
Nov. 1	276	Piazzi, xviii. 79	17 14 56·34	17 14 38·78	−17·56	−13·91	−3·65		
	277	Piazzi, xviii. 79	17 14 56·34	17 14 39·30	−17·04	−13·91	−3·13		
	278	α Aquilæ ..	19 42 45·14	19 42 20·58	−24·56	−13·91	....	−10·65	
8	281	ν Serpentis..	17 11 33·79	17 11 7·62	−26·17	−15·75	....	−10·42	
	282	ν Serpentis..	17 11 33·79	17 11 8·51	−25·28	−15·75	....	− 9·53	

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Computation of the Index Errors in Right Ascension of the Equatoreal (concluded).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Observed Right Ascension affected with Clock Error and Index Error, and sometimes with Refraction.	Clock Error and Index Error, &c.	Computed Clock Error.	Index Error affected with Refraction.	Index Error free from Refraction.	Adopted Index Correction.
1835.			h m s	h m s	s	s		s	s
Nov. 8	283	γ Serpentis..	17 11 33·79	17 11 9·97	−23·82	−15·75	....	− 8·07	+9·22
	284	γ Serpentis..	17 11 33·79	17 11 7·91	−25·88	−15·75	....	− 10·13	
	285	γ Serpentis..	17 11 33·79	17 11 8·09	−25·70	−15·75	....	− 9·95	
	286	γ Serpentis..	17 11 33·79	17 11 8·00	−25·79	−15·75	....	− 10·04	
15	294	γ Serpentis..	17 11 33·78	17 11 18·35	−15·43	− 8·61	....	− 6·82	
	295	γ Serpentis..	17 11 33·78	17 11 18·61	−15·17	− 8·59	....	− 6·58	
	296	γ Serpentis..	17 11 33·78	17 11 17·13	−16·65	− 8·57	....	− 8·08	
	297	γ Serpentis..	17 11 33·78	17 11 16·21	−17·57	− 8·55	....	− 9·02	
	298	η Ophiuchi..	17 0 55·93	17 0 39·12	−16·81	− 8·53	....	− 8·28	
		γ Serpentis..	17 11 33·78	17 11 17·18	−16·60	− 8·52	....	− 8·08	
	299	α Aquilæ ...	19 42 44·95	19 42 26·89	−18·06	− 8·52	....	− 9·54	
	300	α Aquilæ ...	19 42 44·95	19 42 28·27	−16·68	− 8·51	....	− 8·17	
18	302	η Ophiuchi..	17 0 55·94	17 0 46·94	− 9·00	+ 1·03	....	− 10·03	
	303	η Ophiuchi..	17 0 55·94	17 0 46·89	− 9·05	+ 1·04	....	− 10·09	
	304	η Ophiuchi..	17 0 55·94	17 0 46·68	− 9·26	+ 1·06	....	− 10·32	
	305	η Ophiuchi..	17 0 55·94	17 0 47·44	− 8·50	+ 1·07	....	− 9·57	
	306	α Aquilæ ...	19 42 44·92	19 42 35·93	− 8·99	+ 1·09	....	− 10·08	
1836.					m s	m s			
Jan. 15	307	Antares ..	16 19 19·98	16 24 55·10	+5 35·12	+3 44·98	....	+110·14	−105·53
16	308	σ^2 Scorpii ...	16 2 11·13	16 7 48·72	+5 37·59	+3 49·55	....	+108·04	
	309	σ^2 Scorpii ...	16 2 11·13	16 7 44·93	+5 33·80	+3 49·56	....	+104·24	
	310	σ^2 Scorpii ...	16 2 11·13	16 7 33·55	+5 22·42	+3 49·60	....	+ 92·82	
	311	Antares ..	16 19 20·01	16 25 2·23	+5 42·22	+3 49·89	....	+112·42	

Between series 306 (observed on 1835, Nov. 18) and series 307 (observed on 1836, Jan. 15), the position of the pointer appears to have been disturbed 2^m.

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Section IV.

Computations of the Error of the Ephemeris of the Comet in Right Ascension, from Observations reduced with Index Correction.

The right ascensions affected with clock error and instrumental error have been taken from the printed observations, excepting those in series 129, 131, 133, and 240, where $-11^s.96$, $-10^s.06$, $-8^s.41$, and $-2^s.41$, are applied for refraction. The time of transit of the comet in series 173 is diminished by 10^s, and the interpolated right ascension is in consequence diminished by $0^s.65$.

Day.	No. of Series.	Observed Right Ascension of Comet affected with Clock Error and Index Error.	Clock Correction.	Index Correction.	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.		h m s	s	s	h m s	h m s	s
Sept. 27	129	6 27 44·82	+ 2·67	+ 3·69	6 27 51·18	6 27 54·95	+3·77
	131	6 27 50·86	+ 2·65	+ 3·69	6 27 57·20	6 27 58·39	+1·19
30	133	6 39 30·05	+ 4·47	+ 3·69	6 39 38·21	6 39 36·79	−1·42
Oct. 2	135	6 50 45·97	+ 2·62	+ 4·33	6 50 52·92	6 50 51·71	−1·21
	136	6 51 2·20	+ 2·58	+ 4·33	6 51 9·11	6 51 12·09	+2·98
10	166	10 52 9·62	− 3·40	− 2·84	10 52 3·38	10 51 59·87	−3·51
	170	10 55 33·75	− 3·40	− 2·84	10 55 27·51	10 55 24·47	−3·04
	173	11 5 45·19	− 3·40	− 2·84	11 5 38·95	11 5 35·41	−3·54
17	177	16 27 28·28	− 3·94	+ 7·12	16 27 31·36	16 27 29·28	−2·08
	182	16 27 41·05	− 3·90	+ 7·12	16 27 44·27	16 27 43·00	−1·27
	183	16 27 50·85	− 3·85	+ 7·12	16 27 54·12	16 27 52·76	−1·36
18	185	16 38 3·98	− 0·33	+ 4·73	16 38 8·38	16 38 9·09	+0·71
	186	16 38 5·13	− 0·32	+ 4·73	16 38 9·54	16 38 10·15	+0·61
	187	16 38 11·97	− 0·31	+ 4·73	16 38 16·39	16 38 16·96	+0·57
21	221	16 56 28·47	+ 2·77	+ 4·58	16 56 35·82	16 56 35·29	−0·53
	222	16 56 28·85	+ 2·77	+ 4·58	16 56 36·20	16 56 35·87	−0·33

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Computations of the Error of the Ephemeris, &c. reduced with Index Correction (continued).

Day.	No. of Series.	Observed Right Ascension of Comet affected with Clock Error and Index Error.	Clock Correction.	Index Correction.	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
1835.		h m s	s	s	h m s	h m s	s
Oct. 22	232	17 0 27·01	+ 4·76	+ 4·58	17 0 36·35	17 0 36·00	−0·35
	233	17 0 26·13	+ 4·76	+ 4·58	17 0 35·47	17 0 36·45	+0·98
	234	17 0 28·57	+ 4·77	+ 4·58	17 0 37·92	17 0 37·23	−0·69
23	240	17 3 46·77	+ 7·63	+ 5·06	17 3 59·46	17 3 58·42	−1·04
24	245	17 6 24·08	+ 8·09	+ 5·06	17 6 37·23	17 6 34·75	−2·48
Nov. 1	275	17 15 38·34	+ 13·91	+ 9·22	17 16 1·47	17 16 2·22	+0·75
4	279	17 15 56·08	+ 13·99	+ 9·22	17 16 19·29	17 16 18·60	−0·69
	280	17 15 54·97	+ 13·99	+ 9·22	17 16 18·18	17 16 18·57	+0·39
10	287	17 13 20·62	+ 14·63	+ 9·22	17 13 44·47	17 13 46·39	+1·92
12	288	17 11 53·42	+ 12·48	+ 9·22	17 12 15·12	17 12 15·58	+0·46
	289	17 11 52·96	+ 12·48	+ 9·22	17 12 14·66	17 12 15·39	+0·73
	290	17 11 53·28	+ 12·47	+ 9·22	17 12 14·97	17 12 15·27	+0·30
15	291	17 9 13·05	+ 8·64	+ 9·22	17 9 30·91	17 9 30·42	−0·49
	292	17 9 12·84	+ 8·63	+ 9·22	17 9 30·69	17 9 30·24	−0·45
	293	17 9 12·84	+ 8·63	+ 9·22	17 9 30·69	17 9 30·03	−0·66
18	301	17 6 9·04	− 1·01	+ 9·22	17 6 17·25	17 6 18·66	+1·41
1836. Jan. 27	312	15 44 36·77	−284·36	−105·53	15 38 6·88	15 38 16·00	+9·12

For the purpose of ascertaining the error of the transit clock (HARDY), transits were observed on 1836, Jan. 15 and 16 (see Cambridge Observations, 1835, p. 140); but no transits were again observed till after a very long interval. The error of GRAHAM (the clock used with the equatoreal) upon HARDY, on Jan. 27, when series 312 was observed, was known by comparison of the clocks; but the error of HARDY is obtained only by bringing up the error from the 16th with the assumed rate $-1^{s}\cdot20$.

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Section V.

Computations of the Error of the Ephemeris of the Comet in Right Ascension, from Differential Observations with the Mural Circle.

The transits observed with the mural circle are contained on page 215 of the Cambridge Observations, 1835. The time of transit over the mean of wires is there given; but no use is made of the observations taken at the entrance into the field, the passage of the two sides of the comb-plate, or the departure from the field, or of the observations taken at single wires. To supply means for introducing these as available observations, the following equatoreal intervals from the middle wire were computed from the observations of δ *Ursæ Majoris*:—

	s
Entrance into field	+83·04
First edge of comb-plate	+64·74
First wire	+33·33
Second	+16·72
Fourth	−16·56
Fifth	−33·17
Departure from field	−79·86

And thus the following times of transit over the mean of the five wires are obtained:—

		h	m	s
Oct. 10.	Comet from the five wires	22	58	0·70
	a' from the five wires	23	9	9·24
	δ *Ursæ Majoris* from the five wires	0	7	11·38
Oct. 11.	δ *Ursæ Majoris* from the five wires	0	7	13·30
	b' from the second wire	0	35	47·51
	Comet from the five wires	0	40	41·60
	d' from comb-plate, first edge, first wire, fifth wire, and departure	0	41	16·48

Thus the following results are obtained:—

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Day of Observation.	Star's Name or Letter of Reference.	Star's Apparent Right Ascension.	Comet follows Star by	Comet's Deduced Right Ascension.	Comet's Interpolated Right Ascension.	Error of Ephemeris.
		h m s	m s	h m s	h m s	s
Oct. 10	*a'*	11 9 12·83	−11 8·54	10 58 4·29	10 58 0·98	−3·31
	ϑ Ursæ Majoris	12 7 13·25	−69 10·68	10 58 2·57	10 58 0·98	−1·59
11	ϑ Ursæ Majoris	12 7 13·26	+33 28·30	12 40 41·56	12 40 39·57	−1·99
	b'	12 35 47·39	+ 4 54·09	12 40 41·48	12 40 39·57	−1·91
	d'	12 41 18·25	− 0 34·88	12 40 43·37	12 40 39·57	−3·80

Section VI.

Computations of the Error of the Ephemeris of the Comet in North Polar Distance, from Differential Observations only.

In series 143, it is supposed that the micrometer-reading for P ought to be 11·070. In series 172, it is supposed that the circle-reading for the comet ought to be increased 1′. In series 251, it is supposed that the difference of micrometer-readings ought to be diminished two revolutions.

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Comet South of Star by	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835.			° ′ ″	′ ″	° ′ ″	° ′ ″	″
Sept. 2	101	2 Geminorum	66 21 11·36	−89 43·78	64 51 27·58	64 50 39·27	− 48·31
	102	139 Tauri	64 4 25·22	+48 18·93	64 52 44·15	64 50 32·92	−131·23
		2 Geminorum	66 21 11·36	−88 26·52	64 52 44·84	64 50 32·92	−131·92
	103	2 Geminorum	66 21 11·36	−91 12·00	64 49 59·36	64 50 20·89	+ 21·53
20	109	B	59 58 2·66	− 2 33·90	59 55 28·76	59 55 34·95	+ 6·19
	110	B	59 58 2·66	− 2 35·12	59 55 27·54	59 55 20·65	− 6·89
	111	B	59 58 2·66	− 2 34·98	59 55 27·68	59 55 5·16	− 22·52
	112	B	59 58 2·66	− 2 34·82	59 55 27·84	59 55 0·45	− 27·39

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Computations, &c. in North Polar Distance, from Differential Observations only (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Comet South of Star by	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835.			° ′ ″	′ ″	° ′ ″	° ′ ″	″
Sept. 25	120	F	56 51 46·64	+ 5 57·74	56 57 44·38	56 57 30·44	−13·94
	121	F	56 51 46·64	+ 5 2·05	56 56 48·69	56 57 7·96	+19·27
	122	F	56 51 46·64	+ 4 43·88	56 56 30·52	56 56 52·33	+21·81
	123	F	56 51 46·64	+ 4 41·61	56 56 28·25	56 56 28·87	+ 0·62
	127	F	56 51 46·64	+ 4 19·79	56 56 6·43	56 55 33·70	−32·73
30	130	G	55 20 50·19	− 3 22·05	55 17 28·14	55 17 42·19	+14·05
Oct. 2	140	63 Aurigæ ..	50 25 11·23	−106 40·61	48 38 30·62	48 38 53·24	+22·62
4	143	P	44 28 38·36	+ 5 52·04	44 34 30·40	44 34 3·26	−27·14
	144	P	44 28 38·36	+ 4 19·64	44 32 58·00	44 32 53·14	− 4·86
	145	P	44 28 38·36	+ 1 3·02	44 29 41·38	44 30 10·45	+29·07
	146	P	44 28 38·36	− 14·60	44 28 23·76	44 29 1·87	+38·11
5	148	U	41 53 9·59	− 4 56·05	41 48 13·54	41 48 11·67	− 1·87
	149	Q	41 37 6·11	+ 7 41·82	41 44 47·93	41 45 25·76	+37·83
		R	41 45 12·75	− 35·80	41 44 36·95	41 45 25·76	+48·81
	150	R	41 45 12·75	− 3 10·30	41 42 2·45	41 42 14·09	+11·64
		S	41 29 29·07	+ 12 34·56	41 42 3·63	41 42 14·09	+10 46
	151	T	41 27 52·47	+ 13 38·97	41 41 31·44	41 41 18·89	−12·55
		U	41 53 9·59	− 12 1·28	41 41 8·31	41 41 18·89	+10·58
		W	41 29 39·07	+ 11 33·21	41 41 12·28	41 41 18·89	+ 6·61
7	153	Piazzi, viii. 15	35 21 29·14	+ 38·34	35 22 7·48	35 22 9·76	+ 2·28
	154	Piazzi, viii. 15	35 21 29·14	− 22·85	35 21 6·29	35 20 37·01	−29·28
	155	Piazzi, viii. 15	35 21 29·14	− 2 34·77	35 18 54·37	35 18 45·42	− 8·95
	157	Piazzi, viii. 15	35 21 29·14	− 13 46·32	35 7 42·82	35 7 44·06	+ 1·24
		X	34 56 16·11	+ 11 25·81	35 7 41·92	35 7 44·06	+ 2·14
	158	X	34 56 16·11	+ 5 17·97	35 1 34·08	35 1 36·69	+ 2·61
8	160	Y	31 52 16·28	− 3 28·88	31 48 47·40	31 48 50·31	+ 2·91
	161	Y	31 52 16·28	− 5 37·68	31 46 38·60	31 46 51·81	+13·21
	162	Y	31 52 16·28	− 7 23·82	31 44 52·46	31 45 14·13	+21·67
10	165	Z	26 10 41·56	+ 13 11·47	26 23 53·03	26 23 51·68	− 1·35
	166	*b*	23 16 0·59	+185 13·29	26 21 13·88	26 21 7·77	− 6·11
	167	*a*	25 59 50·02	+ 21 45·18	26 21 35·20	26 20 50·94	−44·26

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Computations, &c. in North Polar Distance, from Differential Observations only (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Comet South of Star by	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835.			° ′ ″	′ ″	° ′ ″	° ′ ″	″
Oct. 10	168	α Ursæ Majoris	27 21 50·36	− 61 8·89	26 20 41·47	26 20 37·76	− 3·71
	169	α Ursæ Majoris	27 21 50·36	− 61 22·86	26 20 27·50	26 20 24·75	− 2·75
	171	α Ursæ Majoris	27 21 50·36	− 62 18·16	26 19 32·20	26 19 34·76	+ 2·56
	172	α Ursæ Majoris	27 21 50·36	− 62 32·81	26 19 17·55	26 19 18·38	+ 0·83
	174	*c*	25 58 47·54	+ 20 1·08	26 18 48·62	26 18 42·39	− 6·23
17	178	*e*	70 41 51·56	+ 5 13·04	70 47 4·62	70 45 56·17	−68·45
	180	*d*	70 38 29·05	+ 11 2·82	70 49 31·87	70 48 4·38	−87·49
		e	70 41 51·56	+ 7 32·31	70 49 23·87	70 48 4·38	−79·49
	181	*e*	70 41 51·56	+ 7 50·73	70 49 42·29	70 49 13·19	−29·10
18	188	*g*	76 4 16·13	− 9 27·27	75 54 48·86	75 54 26·24	−22·62
		h	76 2 3·44	− 7 0·38	75 55 3·06	75 54 26·24	−36·82
		i	76 6 37·29	− 11 34·33	75 55 2·96	75 54 26·24	−36·72
	189	*g*	76 4 16·13	− 8 41·00	75 55 35·13	75 55 34·56	− 0·57
		h	76 2 3·44	− 6 18·27	75 55 45·17	75 55 34·56	−10·61
		i	76 6 37·29	− 10 21·83	75 56 15·46	75 55 34·56	−40·90
	190	*g*	76 4 16·13	− 6 59·61	75 57 16·52	75 57 6·25	−10·27
		i	76 6 37·29	− 8 53·51	75 57 43·78	75 57 6·25	−37·53
	191	*g*	76 4 16·13	− 5 25·79	75 58 50·34	75 58 24·06	−26·28
		i	76 6 37·29	− 7 23·40	75 59 13·89	75 58 24·06	−49·83
	192	*i*	76 6 37·29	− 4 37·72	76 1 59·57	76 1 26·76	−32·81
	193	*i*	76 6 37·29	+ 15·76	76 6 53·05	76 6 22·97	−30·08
19	199	ι Ophiuchi .	79 33 24·15	− 3 47·12	79 29 37·03	79 29 13·03	−24·00
	200	ι Ophiuchi .	79 33 24·15	− 3 10·59	79 30 13·56	79 29 48·63	−24·93
	201	ι Ophiuchi .	79 33 24·15	− 2 52·55	79 30 31·60	79 30 6·43	−25·17
	202	ι Ophiuchi .	79 33 24·15	− 2 44·06	79 30 40·09	79 30 23·34	−16·75
	205	ι Ophiuchi .	79 33 24·15	− 1 17·65	79 32 6·50	79 31 32·12	−34·38
	206	ι Ophiuchi .	79 33 24·15	− 56·55	79 32 27·60	79 31 51·81	−35·79
	207	ι Ophiuchi .	79 33 24·15	− 40·64	79 32 43·51	79 32 8·25	−35·26
	208	ι Ophiuchi .	79 33 24·15	− 23·54	79 33 0·61	79 32 19·27	−41·34
	209	ι Ophiuchi .	79 33 24·15	− 14·17	79 33 9·98	79 32 41·39	−28·59
	214	ι Ophiuchi .	79 33 24·15	+ 15 20·25	79 48 44·40	79 48 4·72	−39·68
	215	ι Ophiuchi .	79 33 24·15	+ 15 23·61	79 48 47·76	79 48 17·46	−30·30
	216	ι Ophiuchi .	79 33 24.15	+ 15 30·17	79 48 54·32	79 48 25·92	−28·40
	217	ι Ophiuchi .	79 33 24·15	+ 15 39·69	79 49 3·84	79 48 37·15	−26·69

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Computations, &c. in North Polar Distance, from Differential Observations only (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Comet South of Star by	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835. Oct. 21	223	*l*	85° 20′ 41″·60	+ 6′ 25″·13	85° 27′ 6″·73	85° 26′ 28″·61	−38″·12
	224	*n*	85 19 52·87	+ 8 7·56	85 28 0·43	85 27 21·36	−39·07
	225	*l*	85 20 41·60	+ 8 1·97	85 28 43·57	85 27 59·64	−43·93
	226	*k*	85 24 38·72	+ 4 33·88	85 29 12·60	85 28 31·42	−41·18
		l	85 20 41·60	+ 8 25·19	85 29 6·79	85 28 31·42	−35·37
	227	*l*	85 20 41 60	+ 9 7·71	85 29 49·31	85 29 5·21	−44·10
	228	*l*	85 20 41·60	+ 9 43·30	85 30 24·90	85 29 47·76	−37·14
22	235	*t*	87 37 19·54	+ 6 18·19	87 43 37·73	87 43 3·46	−34·27
	236	*p*	87 40 8·85	+ 4 43·04	87 44 51·89	87 44 14·82	−37·07
		t	87 37 19·54	+ 7 23·02	87 44 42·56	87 44 14·82	−27·74
	237	*p*	87 40 8·85	+ 5 50·33	87 45 59·18	87 45 22·52	−36·66
		t	87 37 19·54	+ 8 37·86	87 45 57·40	87 45 22·52	−34·88
23	238	*o*	89 29 48·65	+11 46·61	89 41 35·26	89 40 59·80	−35·46
		q	89 26 26·84	+14 59·57	89 41 26·41	89 40 59·80	−26·61
	239	*q*	89 26 26·84	+15 16·10	89 41 42·94	89 41 16·37	−26·57
	241	*q*	89 26 26·84	+15 37·67	89 42 4·51	89 41 40·94	−23·57
	242	*q*	89 26 26·84	+15 57·34	89 42 24·18	89 41 51·36	−32·82
24	246	*r*	91 5 57·54	+17 22·95	91 23 20·49	91 22 44·49	−36 00
	247	*u*	91 19 49·63	+ 3 50 60	91 23 40·23	91 23 10·89	−29·34
	248	*u*	91 19 49·63	+ 4 17·54	91 24 7·17	91 23 34·00	−33·17
	249	*u*	91 19 49·63	+ 4 34 52	91 24 24·15	91 23 55·96	−28·19
	250	*u*	91 19 49·63	+ 5 2·94	91 24 52·57	91 24 20·71	−31·86
	251	*u*	91 19 49·63	+ 6 5·64	91 25 55·27	91 25 34·46	−20·81
26	252	A.S.C. 1998	94 56 3″·33	−53 50·88	94 2 12·35	94 1 41·00	−31·35
	253	*v*	93 52 16·56	+11 15·69	94 3 32·25	94 2 58·44	−33·81
		A.S.C. 1998	94 56 3·23	−52 31·30	94 3 31·93	94 2 58·44	−33·49
27	257	A.S.C. 1998	94 56 3·28	+13 18·04	95 9 21·32	95 8 52·54	−28·78
	258	A.S.C. 1998	94 56 3·28	+13 40·24	95 9 43·52	95 9 13·10	−30·42
	259	A.S.C. 1998	94 56 3·28	+13 59·69	95 10 2·97	95 9 35·18	−27·79
	260	*x*	95 9 55·81	+ 39·88	95 10 35·69	95 9 56·45	−39·24
		A.S.C. 1998	94 56 3·28	+14 26·95	95 10 30·23	95 9 56·45	−33·78
	261	*x*	95 9 55·81	+ 1 0·04	95 10 55·85	95 10 26·87	−28·98
		A.S.C. 1998	94 56 3·28	+14 49·98	95 10 53·26	95 10 26·87	−26·39

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Computations, &c. in North Polar Distance, from Differential Observations only (concluded).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Comet South of Star by	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835.			° ′ ″	′ ″	° ′ ″	° ′ ″	″
Oct. 27	262	*x*	95 9 55·81	+ 1 26·72	95 11 22·53	95 10 47·27	−35·26
		A.S.C. 1998	94 56 3·28	+ 15 22·69	95 11 25·97	95 10 47·27	−38·70
29	264	*w*	96 56 17·31	+ 7 28·81	97 3 46·12	97 3 8·80	−37·32
	265	*w*	96 56 17·31	+ 7 33·65	97 3 50·96	97 3 17·81	−33·15
	266	*w*	96 56 17·31	+ 7 38·02	97 3 55·33	97 3 24·81	−30·52
	267	*w*	96 56 17·31	+ 7 44·35	97 4 1·66	97 3 30·12	−31·54
	268	*w*	96 56 17·31	+ 7 53·95	97 4 11·26	97 3 35·37	−35·89
	269	*w*	96 56 17·31	+ 7 58·53	97 4 15·84	97 3 43·59	−32·25
	270	*w*	96 56 17·31	+ 8 10·98	97 4 28·29	97 3 49·81	−38·48
	271	*w*	96 56 17·31	+ 8 13·30	97 4 30·61	97 3 55·93	−34·68
	272	*w*	96 56 17·31	+ 8 32·97	97 4 50·28	97 4 15·96	−34·32
	273	*w*	96 56 17·31	+ 8 40·04	97 4 57·35	97 4 22.27	−35·08
Nov. 1	276	Piazzi, xvii. 79	99 11 49·51	+ 6 17·74	99 18 7·25	99 17 27·41	−39·84
8	281	η Serpentis ..	102 40 19·37	+ 11 2·31	102 51 21·68	102 51 0·03	−21·65
	282	η Serpentis ..	102 40 19·37	+ 11 1·64	102 51 21·01	102 51 5·46	−15·55
	283	η Serpentis ..	102 40 19·37	+ 11 16·93	102 51 36·30	102 51 11·97	−24·33
	284	η Serpentis ..	102 40 19·37	+ 11 19·63	102 51 39·00	102 51 17·19	−21·81
	285	η Serpentis ..	102 40 19·37	+ 11 26·97	102 51 46·34	102 51 22·39	−23·95
15	294	η Serpentis ..	102 40 19·69	+158 4·80	105 18 24·49	105 17 58·67	−25·82
	295	η Serpentis ..	102 40 19·69	+158 7·64	105 18 27·33	105 18 3·26	−24·07
	296	η Serpentis ..	102 40 19·69	+158 9·73	105 18 29·42	105 18 8·51	−20·91
	297	η Serpentis ..	102 40 19·69	+158 11·14	105 18 30·83	105 18 12·76	−18·07
	298	η Ophiuchi ..	105 30 50·09	− 11 56·19	105 18 53·90	105 18 25·83	−28·07
		η Serpentis ..	102 40 19·69	+158 18·44	105 18 38·13	105 18 25·83	−12·30
18	302	η Ophiuchi ..	105 30 50·18	+ 39 45·40	106 10 35·58	106 10 18·12	−17·46
	303	η Ophiuchi ..	105 30 50·18	+ 39 43·31	106 10 33·49	106 10 24·09	− 9·40
	304	η Ophiuchi ..	105 30 50·18	+ 40 11·14	106 11 1·32	106 10 30·41	−30·91
	305	η Ophiuchi ..	105 30 50·18	+ 40 22·70	106 11 12·88	106 10 36·32	−36·56
1836.							
Jan. 16	308	c^2 Scorpii....	117 29 35·19	+ 2 32·61	117 32 7·80	117 32 54·05	+46·25
	309	c^2 Scorpii....	117 29 35·19	+ 3 12·92	117 32 48·11	117 32 59·60	+11·49
	310	c^2 Scorpii....	117 29 35·19	+ 3 38·41	117 33 13·60	117 33 4·27	− 9·33

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It will be seen in the next section that the index errors given by the stars in series 101, 102, are good; the discordances in the results arise, therefore, from errors of observation of the comet. From series 178 to series 193 the index errors are very irregular, while the results for the comet, reduced by a general index error, are good: here it is evident that the stars were badly observed.

SECTION VII.

Computation of the Index Errors in North Polar Distance of the Equatoreal.

In series 143, the micrometer reading for P is increased by two revolutions, as in section 6. In series 251, the micrometer reading for u is diminished by two revolutions; but the index error given by this observation is not included in the group for forming the mean index error.

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Star's Observed North Polar Distance.	Index Error.	Adopted Index Correction.
1835. Sept. 2	101	2 Geminorum	66° 21′ 11″·36	66° 24′ 35″·31	+3′ 23″·95	−3′ 34″·29
	102	139 Tauri	64 4 25·22	64 8 4·20	+3 38·98	
		2 Geminorum	66 21 11·36	66 24 49·65	+3 38·29	
	103	2 Geminorum	66 21 11·36	66 24 51·15	+3 39·79	
20	109	B	59 58 2·66	60 1 56·03	+3 53·37	
	110	B	59 58 2·66	60 1 54·17	+3 51·51	
	111	B	59 58 2·66	60 1 36·30	+3 33·64	
	112	B	59 58 2·66	60 1 30·42	+3 27·76	
	116	2 Aurigæ ...	59 24 47·31	59 28 37·75	+3 50·44	
25	120	F	56 51 46·64	56 55 14·83	+3 28·19	
	121	F	56 51 46·64	56 55 21·54	+3 34·90	
	122	F	56 51 46·64	56 55 25·66	+3 39·02	
	123	F	56 51 46·64	56 55 14·86	+3 28·22	
	126	A.S.C. 808 ..	57 26 1·38	57 29 28·73	+3 27·35	
	127	F	56 51 46·64	56 55 24·20	+3 37·56	
27	130	G	55 20 50·19	55 24 41·64	+3 51·45	

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Computation of the Index Errors in North Polar Distance of the Equatoreal (*continued*).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Star's Observed North Polar Distance.	Index Error.	Adopted Index Correction.
1835.			° ′ ″	° ′ ″	′ ″	′ ″
Oct. 2	139	64 Aurigæ ..	48 49 58·75	48 53 31·65	+3 32·90	−3 34·29
	140	63 Aurigæ ..	50 25 11·23	50 28 28·07	+3 16·84	
4	143	P	44 28 38·36	44 32 6·06	+3 27·70	
	144	P	44 28 38·36	44 32 17·79	+3 39·43	
	145	P	44 28 38·36	44 32 8·21	+3 29·85	
5	148	U	41 53 9·59	41 56 35·67	+3 26·08	
	149	Q	41 37 6·11	41 40 13·26	+3 7·15	
		R	41 45 12·75	41 48 30·88	+3 18·13	
	150	R	41 45 12·75	41 48 48·55	+3 35·80	
		S	41 29 29·07	41 33 3·69	+3 34·62	
	151	T	41 27 52·47	41 30 56·74	+3 4·27	
		U	41 53 9·59	41 56 36·99	+3 27·40	
		W	41 29 39·07	41 33 2·50	+3 23·43	
7	153	Piazzi, viii. 15	35 21 29·14	35 25 6·44	+3 37·30	
	155	Piazzi, viii. 15	35 21 29·14	35 24 55·12	+3 25·98	
	157	Piazzi, viii. 15	35 21 29·14	35 24 53·51	+3 24·37	
		X	34 56 16·11	34 59 41·38	+3 25·27	
	158	X	34 56 16·11	34 59 34·12	+3 18·01	
8	160	Y	31 52 16·28	31 55 51·93	+3 35·65	
	161	Y	31 52 16·28	31 55 54·24	+3 37·96	
	162	Y	31 52 16·28	31 56 1·86	+3 45·58	
10	165	Z	26 10 41·56	26 14 40·01	+3 58·45	
	166	*b*	23 16 0·59	23 19 54·95	+3 54·36	
	167	*a*	25 59 50·02	26 3 33·57	+3 43·55	
	168	α Ursæ Majoris	27 21 50·36	27 25 29·58	+3 39·22	
	169	α Ursæ Majoris	27 21 50·36	27 25 36·62	+3 46·26	
	171	α Ursæ Majoris	27 21 50·36	27 25 46·65	+3 56·29	
	172	α Ursæ Majoris	27 21 50·36	27 25 42·14	+3 51·78	
	174	*c*	25 58 47·54	26 2 2·43	+3 14·89	
17	178	*e*	70 41 51·56	70 41 59·84	+ 8·28	− 42·01
	180	*d*	70 38 29·05	70 38 50·42	+ 21·37	
		e	70 41 51·56	70 42 20·93	+ 29·37	

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Computation of the Index Errors in North Polar Distance of the Equatoreal (continued).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Star's Observed North Polar Distance.	Index Error.	Adopted Index Correction.
1835. Oct. 17	181	*e*	70° 41′ 51″·56	70° 42′ 40″·90	+ ′ 49″·34	— ′ 42″·01
18	188	*g*	76 4 16·13	76 5 8·29	+ 52·16	
		h	76 2 3·44	76 2 41·40	+ 37·96	
		i	76 6 37·29	76 7 15·35	+ 38·06	
	189	*g*	76 4 16·13	76 5 26·98	+1 10·85	
		h	76 2 3·44	76 3 4·25	+1 0·81	
		i	76 6 37·29	76 7 7·81	+ 30·52	
	190	*g*	76 4 16·13	76 5 21·97	+1 5·84	
		i	76 6 37·29	76 7 15·87	+ 38·58	
	191	*g*	76 4 16·13	76 5 16·84	+1 0·71	
		i	76 6 37·29	76 7 14·45	+ 37·16	
	192	*i*	76 6 37·29	76 7 3·50	+ 26·21	
	193	*i*	76 6 37·29	76 7 22·28	+ 44·99	
19	199	*i* Ophiuchi .	79 33 24·15	79 34 7·23	+ 43·08	— 43·27
	200	*i* Ophiuchi .	79 33 24·15	79 34 10·58	+ 46·43	
	201	*i* Ophiuchi .	79 33 24·15	79 34 5·37	+ 41·22	
	202	*i* Ophiuchi .	79 33 24·15	79 34 9·20	+ 45·05	
	205	*i* Ophiuchi .	79 33 24·15	79 34 5·97	+ 41·82	
	206	*i* Ophiuchi .	79 33 24·15	79 34 4·44	+ 40·29	
	207	*i* Ophiuchi .	79 33 24·15	79 34 7·36	+ 43·21	
	208	*i* Ophiuchi .	79 33 24·15	79 34 6·76	+ 42·61	
	209	*i* Ophiuchi .	79 33 24·15	79 34 9·84	+ 45·69	
21	223	*l*	85 20 41·60	85 21 42·88	+1 1·28	—1 3·23
	224	*n*	85 19 52·87	85 20 54·83	+1 1·96	
	225	*l*	85 20 41·60	85 21 40·32	+ 58·72	
	226	*k*	85 24 38·72	85 25 36·45	+ 57·73	
		l	85 20 41·60	85 21 45·14	+1 3·54	
	227	*l*	85 20 41·60	85 21 43·45	+1 1·85	
	228	*l*	85 20 41·60	85 21 45·25	+1 3·65	
22	235	*t*	87 37 19·54	87 38 16·40	+ 56·86	
	236	*p*	87 40 8·85	87 40 59·52	+ 50·67	
		t	87 37 19·54	87 38 19·54	+1 0·00	
	237	*p*	87 40 8·85	87 41 13·79	+1 4·94	
		t	87 37 19·54	87 38 26·26	+1 6·72	

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Computation of the Index Errors in North Polar Distance of the Equatoreal (*continued*).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Star's Observed North Polar Distance.	Index Error.	Adopted Index Correction.
1835.			° ′ ″	° ′ ″	′ ″	′ ″
Oct. 23	238	*o*	89 29 48·65	89 30 47·88	+ 59·23	−1 3·23
		q	89 26 26·84	89 27 34·92	+1 8·08	
	239	*q*	89 26 26·84	89 27 29·21	+1 2·37	
	241	*q*	89 26 26·84	89 27 26·79	+ 59·95	
	242	*q*	89 26 26·84	89 27 26·25	+ 59·41	
24	246	*r*	91 5 57·54	91 7 4·79	+1 7·25	
	247	*u*	91 19 49·63	91 21 5·42	+1 15·79	
	248	*u*	91 19 49·63	91 20 58·81	+1 9·18	
	249	*u*	91 19 49·63	91 21 1·20	+1 11·57	
	250	*u*	91 19 49·63	91 20 59·83	+1 10·20	
	251	*u*	91 19 49·63	91 21 15·56	+1 25·93	
26	252	A.S.C. 1998	94 56 3·23	95 1 50·57	+5 47·34	−5 47·81
	253	*v*	93 52 16·56	93 58 4·44	+5 47·88	
		A.S.C. 1998	94 56 3·23	95 1 51·43	+5 48·20	
27	257	A.S.C. 1998	94 56 3·28	95 1 26·52	+5 23·24	−5 20·31
	258	A.S.C. 1998	94 56 3·28	95 1 24·98	+5 21·70	
	259	A.S.C. 1998	94 56 3·28	95 1 27 77	+5 24·49	
	260	*x*	95 9 55·81	95 15 13·74	+5 17·93	
		A.S.C. 1998	94 56 3·28	95 1 26·67	+5 23·39	
	261	*x*	95 9 55·81	95 15 18·24	+5 22·43	
		A.S.C. 1998	94 56 3·28	95 1 28·30	+5 25·02	
	262	*x*	95 9 55·81	95 15 21·94	+5 26·13	
		A.S.C. 1998	94 56 3·28	95 1 25·97	+5 22·69	
29	264	*w*	96 56 17·31	97 1 37·41	+5 20·10	
	265	*w*	96 56 17·31	97 1 39·89	+5 22·58	
	266	*w*	96 56 17·31	97 1 41·15	+5 23·84	
	267	*w*	96 56 17·31	97 1 42·18	+5 24·87	
	268	*w*	96 56 17·31	97 1 39·47	+5 22·16	
	269	*w*	96 56 17·31	97 1 41·68	+5 24·37	
	270	*w*	96 56 17·31	97 1 36·14	+5 18·83	
	271	*w*	96 56 17·31	97 1 40·84	+5 23·53	
	272	*w*	96 56 17·31	97 1 37·27	+5 19·96	
	273	*w*	96 56 17·31	97 1 34·90	+5 17·59	

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Computation of the Index Errors in North Polar Distance of the Equatoreal (concluded).

Day.	No. of Series.	Star's Name or Letter of Reference.	Star's Apparent North Polar Distance.	Star's Observed North Polar Distance.	Index Error.	Adopted Index Correction.
1835. Nov. 1	276	Piazzi, xvii. 79	99° 11′ 49″·51	99° 17′ 0″·52	+5′ 11″·01	−5′ 20″·31
8	281	ρ Serpentis ..	102 40 19·37	102 45 42·13	+5 22·76	
	282	ρ Serpentis ..	102 40 19·37	102 45 49·02	+5 29·65	
	283	ρ Serpentis ..	102 40 19·37	102 45 41·75	+5 22·38	
	284	ρ Serpentis ..	102 40 19·37	102 45 43·54	+5 24·17	
	285	ρ Serpentis ..	102 40 19·37	102 45 45·40	+5 26·03	
15	294	ρ Serpentis ..	102 40 19·69	102 45 33·05	+5 13·36	
	295	ρ Serpentis ..	102 40 19·69	102 45 35·21	+5 15·52	
	296	ρ Serpentis ..	102 40 19·69	102 45 35·70	+5 16·01	
	297	ρ Serpentis ..	102 40 19·69	102 45 35·13	+5 15·44	
	298	η Ophiuchi ..	105 30 50·07	105 35 49·33	+4 59·24	
		ρ Serpentis ..	102 40 19·69	102 45 34·70	+5 15·01	
18	302	η Ophiuchi ..	105 30 50·18	105 36 14·65	+5 24·47	
	303	η Ophiuchi ..	105 30 50·18	105 36 9·50	+5 19·32	
	304	η Ophiuchi ..	105 30 50·18	105 36 8·88	+5 18·70	
	305	η Ophiuchi ..	105 30 50·18	105 36 2·83	+5 12·65	
1836. Jan. 16	308	c^2 Scorpii	117 29 35·19	117 35 28·20	+5 53·01	−5 20·34
	309	c^2 Scorpii	117 29 35·19	117 34 58·51	+5 23·32	
	310	c^2 Scorpii	117 29 35·19	117 34 43·97	+5 8·78	
	311	Antares ...	116 3 38·12	116 8 34·36	+4 56·24	

Section VIII.

Computations of the Error of the Ephemeris of the Comet in North Polar Distance, from Observations reduced with Index Correction.

As in Section IV., these reductions are applied only to those series in which the comet was observed without a star, or in which the observations

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of the star are unsatisfactory. In series 172 and 187, the observed north polar distance of the comet is increased 1′; probably the same ought to have been done in series 149.

Day.	No. of Series.	Comet's Observed North Polar Distance.	Index Correction.	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835.		° ′ ″	′ ″	° ′ ″	° ′ ″	″
Sept. 2	100	64 55 32·26	−3 34·29	64 51 57·97	64 50 47·13	−70·84
27	130	55 21 19·59		55 17 45·30	55 17 42·19	− 3·11
	131	55 20 34·00		55 16 59·71	55 17 4·39	+ 4·68
30	133	51 57 2·11		51 53 27·82	51 53 37·96	+10·14
Oct. 2	134	48 56 56·41		48 53 22·12	48 53 10·35	−11·77
	137	48 49 31·31		48 45 57·02	48 46 20·99	+23·97
	138	48 49 5·94		48 45 31·65	48 46 3·15	+31·50
4	143	44 37 58·10		44 34 23·81	44 34 3·26	−20·55
5	148	41 51 39·62		41 48 5·33	41 48 11·67	+ 6·34
	149	41 47 55·08		41 44 20·79	41 45 25·76	+64·97
8	162	31 48 38·04		31 45 3·75	31 45 14·13	+10·38
10	167	26 25 18·75		26 21 44·46	26 20 50·94	−53·52
	170	26 23 10·61		26 19 36·32	26 19 48·43	+12·11
	172	26 23 9·24		26 19 34·95	26 19 18·38	−16·57
	173	26 21 29·47		26 17 55·18	26 17 37·91	−17·27
17	177	70 45 40·46	− 42·01	70 44 58·45	70 44 24·33	−34·12
	178	70 47 12·90		70 46 30·89	70 45 56·17	−34·72
	180	70 49 53·24		70 49 11·23	70 48 4·38	−66·85
	181	70 50 31·63		70 49 49·62	70 49 13·19	−36·43
	182	70 51 53·74		70 51 11·73	70 50 39·99	−31·74
	183	70 56 35·10		70 55 53·09	70 55 16·59	−36·50
18	186	75 49 26·30		75 48 44·29	75 48 14·14	−30·15
	187	75 52 52·58		75 52 10·57	75 51 34·93	−35·64
	188	75 55 41·02		75 54 59·01	75 54 26·24	−32·77
	189	75 56 45·98		75 56 3·97	75 55 34·56	−29·41
	190	75 58 22·36		75 57 40·35	75 57 6·25	−34·10
	191	75 59 51·05		75 59 9·04	75 58 24·06	−44·98

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Computations of the Error, &c. from Observations reduced with Index Correction (concluded).

Day.	No. of Series.	Comet's Observed North Polar Distance.	Index Correction.	Comet's Deduced North Polar Distance.	Comet's Interpolated North Polar Distance.	Error of Ephemeris.
1835.		° ′ ″	′ ″	° ′ ″	° ′ ″	″
Oct. 21	222	85 27 24·37	−1 3·23	85 26 21·14	85 25 51·61	−27·53
	229	85 40 37·74		85 39 34·51	85 38 44·39	−50·12
22	233	87 43 47·91		87 42 44·68	87 42 15·75	−28·93
	234	87 44 19·47		87 43 16·24	87 42 43·01	−33·2
23	240	89 42 56·26		89 41 53·03	89 41 27·78	−25·25
24	245	91 19 28·84		91 18 25·61	91 17 51·19	−34·42
	251	91 27 21·20		91 26 17·97	91 25 34·46	−43·51
26	254	94 9 49·06	−5 47·81	94 4 1·25	94 3 32·14	−29·11
	255	94 10 49·12		94 5 1·31	94 4 26·12	−35·19
Nov. 1	275	99 21 45·53	−5 20·31	99 16 25·22	99 15 53·30	−31·92
	277	99 23 27·83		99 18 7·52	99 17 42·95	−24·57
4	279	101 6 51·31		101 1 31·00	101 1 9·16	−21·84
10	287	103 43 32·31		103 38 12·00	103 38 0·21	−11·79
12	288	104 25 53·72		104 20 33·41	104 20 9·03	−24·38
	289	104 25 59·27		104 20 38·96	104 20 13·73	−25·23
	290	104 26 10·42		104 20 50·11	104 20 16·70	−33·41
15	291	105 23 14·46		105 17 54·15	105 17 49·38	− 4·77
	292	105 23 25·17		105 18 4·86	105 17 52·82	−12·04
	293	105 23 34·56		105 18 14·25	105 17 56·54	−17·71
18	301	106 15 54·87		106 10 34·56	106 10 10·27	−24·29
1836.						
Jan. 16	308	117 38 0·81	−5 20·34	117 32 40·47	117 32 54·05	+13·58
	309	117 38 11·43		117 32 51·09	117 32 59·60	+ 8·51
	310	117 38 22·38		117 33 2·04	117 33 4·27	+ 2·23
27	312	119 35 5·65		119 29 45·31	119 28 45·66	−59·65

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Section IX.

Collection of all the Results obtained in the preceding Sections for the Errors of the Ephemeris.

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	Error of Ephemeris. In Right Ascension. By Index Error.	Error of Ephemeris. In North Polar Dist. By Diff. Obs.	Error of Ephemeris. In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
100	Sept. 2 13 46 27	+43·29			−70·84	A	
101	2 14 5 52	+ 1·47		− 48·31		2 Geminorum	
102	2 14 21 19	+ 1·80				139 Tauri	
		+ 1·48				2 Geminorum	
	14 21 34			−131·92		2 Geminorum	
				−131·23		139 Tauri	
103	2 14 51 17	− 5·70		+ 21·53		2 Geminorum	
104	20 10 48 26	+ 2·57				B	
105	20 10 57 16	− 0·10				B	
106	20 11 1 17	+ 0·93				B	
107	20 11 5 15	+ 0·19				B	
108	20 11 9 26	− 1·28				B	
109	20 11 19 32			+ 6·19		B	
110	20 11 31 35			− 6·89		B	
111	20 11 44 38			− 22·52		B	
112	20 11 48 36			− 27·39		B	
113	20 11 53 45	+ 1·26				B	
114	20 12 1 11	+ 2·26				B	
118	25 10 23 12	+ 2·27				E	
		+ 3·58				F	
119	25 10 30 12	− 0·75				E	
		+ 1·06				F	
120	25 10 38 0			− 13·94		F	
121	25 10 49 59			+ 19·27		F	
122	25 10 58 17			+ 21·81		F	
123	25 11 10 45			+ 0·62		F	
124	25 11 20 11	− 0·31				E	
		+ 0·50				F	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	In Right Ascension. By Index Error.	In North Polar Dist. By Diff. Obs.	In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
125	Sept. 25 11 27 20	+10·63				C	125. There is some error in regard to C.
		− 2·52				D	
		− 3·58				E	
		− 1·77				F	
127	25 11 40 13	+ 0·29		−32·73		F	
129	27 10 9 5	− 0·35	+3·77			H	129. H gives a bad index error.
		+13·67				J	
130	27 10 19 27			+14·05	− 3·11	G	129. The place of J is doubtful, but it gives a good index error.
131	27 10 35 39	+16·73	+1·19		+ 4·68	J	131. The star is called K in the observations; it is assumed here to be the same as J.
133	30 10 49 25	+ 1·29	−1·42		+10·14	M	133. O gives a bad index error.
		− 0·21				N	
		− 7·56				O	
134	Oct. 2 9 13 20				−11·77		
135	2 9 19 33		−1·21				
136	2 10 29 15		+2·98				
137	2 10 44 50				+23·97		
138	2 10 48 48				+31·50		
140	2 12 23 24	+ 3·19				63 Aurigæ	
	12 23 56			+22·62		63 Aurigæ	
143	4 10 48 38			−27·14	−20·55	P	143. The micrometer reading for P is increased 2′.
144	4 11 0 7			− 4·86		P	
	11 1 21	− 0·46				P	
145	4 11 26 42			+29·07		P	
	11 27 57	+ 0·88				P	
146	4 11 37 53			+38·11		P	
148	5 11 50 56	+ 0·49		− 1·87	+ 6·34	U	
149	5 12 14 2			+37·83	+64·97	Q	149. Probably the comet's N.P.D. ought to be increased 1′.
				+48·81		R	
	12 15 19	− 1·15				Q	
		− 1·82				R	
		− 0·55				S	
150	5 12 40 39	− 1·08		+11·64		R	
		+ 0·69		+10·46		S	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	Error of Ephemeris. In Right Ascension. By Index Error.	Error of Ephemeris. In North Polar Dist. By Diff. Obs.	Error of Ephemeris. In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
151	Oct. 5 12 48 18			−12·55		T	
				+10·58		U	
				+ 6·61		W	
	12 49 36	+ 1·02				T	
		− 2·86				U	
		+ 0·28				W	
153	7 10 40 35	− 3·96		+ 2·28		Piazzi, viii. 15	
154	7 10 50 38	− 0·94		−29·28		Piazzi, viii. 15	
155	7 11 2 43			− 8·95		Piazzi, viii. 15	
156	7 12 5 52	− 2·98				Piazzi, viii. 15	
		− 0·80				X	
157	7 12 14 10	+ 3·07		+ 1·24		Piazzi, viii. 15	157. The time for the first star is diminished 1^m.
				+ 2·14		X	
158	7 12 53 44			+ 2·61		X	
	12 55 15	+ 0·98				X	
Merid. Obs.	8 7 29 36		−2·41		−22·90		
160	8 9 14 48			+ 2·91		Y	
	9 15 37	− 1·00				Y	
161	8 9 27 18	− 2·17		+13·21		Y	
162	8 9 37 36	− 2·45		+21·67	+10·38	Y	
Merid. Obs.	9 8 21 40		+0·34		+22·6		
165	10 6 43 50	− 4·75		− 1·35		Z	
166	10 8 8 32	+12·60	−3·51	− 6·11		*b*	166. Some error in regard to *b*.
167	10 8 18 56	− 1·16		−44·26	−53·52	*a*	
168	10 8 27 22	− 3·84		− 3·71		α Ursæ Majoris	
169	10 8 36 0	− 2·91		− 2·75		α Ursæ Majoris	
170	10 9 1 57		−3·04		+12·11		
171	10 9 12 35	− 3·07		+ 2·56		α Ursæ Majoris	
172	10 9 26 8	− 1·09		+ 0·83	−16·57	α Ursæ Majoris	172. The circle-reading for the comet is increased 1′.
Merid. Obs.	10 9 42 35	− 3·31	−1·62		+11·73	*a′*	
		− 1·59				δ Ursæ Majoris	
173	10 11 39 16		−3·54		−17·27		173. The comet's transit is diminished 10^s.
174	10 14 51 8	− 2·83		− 6·23		*c*	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	In Right Ascension. By Index Error.	In North Polar Dist. By Diff. Obs.	In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
Merid. Obs.	1835. d h m s Oct. 11 11 21 3	s −1·99	s −3·70	"	" + 0·24	ϑ Ursæ Majoris	
		−1·91				*b'*	
		−3·80				*d'*	
177	17 5 48 54		−2·08		−34·12		
178	17 5 55 48	−0·79		−68·45	−34·72	*e*	
179	17 6 0 44	−1·24				*e*	
180	17 6 5 26	−2·09		−87·49	−66·85	*d*	
		−1·72		−79·49		*e*	
181	17 6 9 54	−1·01				*e*	
	6 10 37			−29·10	−36·43	*e*	
182	17 6 17 9		−1·27		−31·74		
183	17 6 37 22		−1·36				
	6 38 2				−36·50		
185	18 7 6 53		+0·71				
186	18 7 9 47		+0·61		−30·15		
187	18 7 28 29		+0·57		−35·64		187. The comet's N.P.D. is increased 1'.
188	18 7 44 28	−0·25		−22·62	−32·77	*g*	
		+0·46		−36·82		*k*	
		−0·23		−36·72		*i*	
189	18 7 50 51	0·00		− 0·57	−29·41	*g*	
		+0·57		−10·61		*k*	
		−0·06		−40·90		*i*	
190	18 7 59 26	−0·40		−10·27	−34·10	*g*	
		+0·11		−37·53		*i*	
191	18 8 6 44	−0·27		−26·28	−44·98	*g*	
		+0·03		−49·83		*i*	
192	18 8 23 52	+0·45		−32·81		*i*	
193	18 8 51 44	+0·98		−30·08		*i*	193. The star is called *f* in the observations: it is assumed to be the same as *i*, with an error of 5m.
197	19 5 34 38	−1·53				*i* Ophiuchi	
198	19 5 38 30	−1·74				*i* Ophiuchi	
199	19 5 42 6			−24·00		*i* Ophiuchi	
200	19 5 46 5			−24·93		*i* Ophiuchi	
201	19 5 48 5			−25·17		*i* Ophiuchi	
202	19 5 49 59			−16·75		*i* Ophiuchi	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	Error of Ephemeris. In Right Ascension. By Index Error.	Error of Ephemeris. In North Polar Dist. By Diff. Obs.	Error of Ephemeris. In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
203	Oct. 19 5 51 16	−1·17				*i* Ophiuchi	
204	19 5 54 44	−1·27				*i* Ophiuchi	
205	19 5 57 41	−1·85		−34·38		*i* Ophiuchi	
206	19 5 59 54			−35·79		*i* Ophiuchi	
207	19 6 1 45	−1·79		−35·26		*i* Ophiuchi	
208	19 6 2 59			−41·34		*i* Ophiuchi	
209	19 6 5 28	−1·79		−28·59		*i* Ophiuchi	
210	19 6 8 17	−1·34				*i* Ophiuchi	
211	19 6 11 31	−0·91				*i* Ophiuchi	
212	19 7 40 38	+2·76				*i* Ophiuchi	
213	19 7 46 55	+1·54				*i* Ophiuchi	
214	19 7 49 55	−1·04		−39·68		*i* Ophiuchi	
215	19 7 51 22	−1·11		−30·30		*i* Ophiuchi	
216	19 7 52 20	−2·85		−28·40		*i* Ophiuchi	
217	19 7 53 36	−0·53		−26·69		*i* Ophiuchi	
218	19 7 54 51	+1·77				*i* Ophiuchi	
221	21 5 32 2		−0·53				
222	21 5 35 11		−0·33		−27·53		
223	21 5 41 9	−0·47		−38·12		*l*	
224	21 5 49 41	−1·42		−39·07		*n*	
225	21 5 55 53	−0·34		−43·93		*l*	
226	21 6 1 1	−1·03		−41·18		*k*	
		−0·91		−35·37		*l*	
227	21 6 6 30	−0·67		−44·10		*l*	
228	21 6 13 24	−0·54		−37·14		*l*	
229	21 7 40 55	−2·35			−50·12	*m*	229. The star's transit is increased 1m.
232	22 5 29 1		−0·35				
233	22 5 32 1		+0·98		−28·93		
234	22 5 37 13		−0·69		−33·23		
235	22 5 40 42	−0·31				*t*	
	5 41 7			−34·27		*t*	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	In Right Ascension. By Index Error.	In North Polar Dist. By Diff. Obs.	In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
236	Oct. 22 5 54 20	−0·01				*p*	
		+0·22				*t*	
	5 54 46			−37·07		*p*	
				−27·74		*t*	
237	22 6 7 17	−0·32				*p*	
		−0·13				*t*	
	6 7 43			−36·66		*p*	
				−34·88		*t*	
238	23 6 3 55	−0·98				*o*	
		−0·02				*q*	
	6 4 20			−35·46		*o*	
				−26·61		*q*	
239	23 6 7 37	−0·10				*q*	
	6 8 3			−26·57		*q*	
240	23 6 10 11		−1·04				
	6 10 36				−25·25		
241	23 6 13 7	0·00				*q*	
	6 13 33			−23·57		*q*	
242	23 6 15 27	+0·32				*q*	
	6 15 53			−32·82		*q*	
245	24 5 19 59		−2·48				
	5 20 25				−34·42		
246	24 6 35 51	+1·54				*r*	
		−0·06				*s*	
	6 36 17			−36·00		*r*	
247	24 6 42 49	−0·82				*u*	
	6 43 15			−29·34		*u*	
248	24 6 48 44	−0·24				*u*	
	6 49 9			−33·17		*u*	
249	24 6 54 25	−0·42				*u*	
	6 54 52			−28·19		*u*	
250	24 7 0 52	−0·93				*u*	
	7 1 18			−31·86		*u*	
251	24 7 20 5	−0·96				*u*	251. The micrometer-reading is diminished 2r for the star.
	7 20 31			−20·77	−43·51	*u*	
252	26 5 31 58	+0·20				A.S.C. 1998	
	5 32 25			−31·35		A.S.C. 1998	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	Error of Ephemeris. In Right Ascension. By Index Error.	Error of Ephemeris. In North Polar Dist. By Diff. Obs.	Error of Ephemeris. In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
253	Oct. 26 5 57 59	−0·26				*v*	
		−0·03				A.S.C. 1998	
	5 58 26			−33·81		*v*	
				−33·49		A.S.C. 1998	
254	26 6 9 20	−0·28				*v*	
	6 9 46				−29·11		
255	26 6 27 32	+0·56				A.S.C. 1998	
	6 27 58				−35·19		
257	27 5 27 59	−0·53				A.S.C. 1998	
	5 28 26			−28·78		A.S.C. 1998	
258	27 5 35 46	−0·15				A.S.C. 1998	
	5 36 12			−30·42		A.S.C. 1998	
259	27 5 44 7	−0·69				A.S.C. 1998	
	5 44 33			−27·79		A.S.C. 1998	
260	27 5 52 11	+0·09				*x*	
		+0·63				A.S.C. 1998	
	5 52 36			−39·24		*x*	
				−33·78		A.S.C. 1998	
261	27 6 3 41	−0·75				*x*	
		−0·63				A.S.C. 1998	
	6 4 7			−28·98		*x*	
				−26·39		A.S.C. 1998	
262	27 6 11 25	−0·63				*x*	
		−0·25				A.S.C. 1998	
	6 11 51			−35·26		*x*	
				−38·70		A.S.C. 1998	
264	29 5 34 47	−0·31				*w*	
	5 35 14			−37·32		*w*	
265	29 5 39 1	−0·52				*w*	
	5 39 27			−33·15		*w*	
266	29 5 42 17	−0·76				*w*	
	5 42 44			−30·52		*w*	
267	29 5 44 47	−0·93				*w*	
	5 45 13			−31·54		*w*	
268	29 5 47 15	−0·92				*w*	
	5 47 41			−35·89		*w*	
269	29 5 51 7	−0·67				*w*	
	5 51 32			−32·25		*w*	

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Collection of all the Results, &c. for the Errors of the Ephemeris (continued).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	Error of Ephemeris. In Right Ascension. By Index Error.	Error of Ephemeris. In North Polar Dist. By Diff. Obs.	Error of Ephemeris. In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
270	Oct. 29 5 54 1	−0·55				*w*	
	5 54 27			−38·48		*w*	
271	29 5 56 54	−0·83				*w*	
	5 57 20			−34·68		*w*	
272	29 6 6 18	−0·34				*w*	
	6 6 44			−34·32		*w*	
273	29 6 9 17	−0·41				*w*	
	6 9 42			−35·08		*w*	
275	Nov. 1 4 55 53		+0·75		−31·92		
276	1 5 53 24	−0·21				Piazzi, xvii. 79	
	5 53 49			−39·84		Piazzi, xvii. 79	
277	1 6 3 0	+0·13				Piazzi, xvii. 79	
	6 3 25				−24·57		
279	4 5 31 39		−0·69		−21·84		
280	4 5 38 8		+0·39				
281	8 5 10 42	−0·33				ρ Serpentis	
	5 11 8			−21·65		ρ Serpentis	
282	8 5 16 1	+0·34				ρ Serpentis	
	5 16 27			−15·55		ρ Serpentis	
283	8 5 22 22	−0·38				ρ Serpentis	
	5 22 48			−24·33		ρ Serpentis	
284	8 5 27 28	−0·08				ρ Serpentis	
	5 27 55			−21·81		ρ Serpentis	
285	8 5 32 34	−0·19				ρ Serpentis	
	5 33 0			−23·95		ρ Serpentis	
286	8 5 37 32	+0·20				ρ Serpentis	
287	10 5 29 59		+1·92				
	5 30 25				−11·79		
288	12 5 0 1		+0·46				
	5 0 28				−24·38		
289	12 5 5 33		+0·73				
	5 5 59				−25·23		
290	12 5 9 2		+0·30				
	5 9 29				−33·41		
291	15 4 44 12		−0·49				
	4 44 38				− 4·77		

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Collection of all the Results, &c. for the Errors of the Ephemeris (concluded).

No. of Series.	Greenwich Mean Solar Time.	Error of Ephemeris. In Right Ascension. By Diff. Obs.	In Right Ascension. By Index Error.	In North Polar Dist. By Diff. Obs.	In North Polar Dist. By Index Error.	Reference to Star used for Differential Observations.	Remarks.
	1835. d h m s	s	s	"	"		
292	Nov. 15 4 48 44		−0·45				
	4 49 11				−12·04		
293	15 4 53 36		−0·66				
	4 54 3				−17·71		
294	15 4 56 24	−0·67				ρ Serpentis	
	4 56 51			−25·82		ρ Serpentis	
295	15 5 2 26	−0·45				ρ Serpentis	
	5 2 53			−24·07		ρ Serpentis	
296	15 5 9 19	−0·50				ρ Serpentis	
	5 9 47			−20·91		ρ Serpentis	
297	15 5 14 55	−0·36				ρ Serpentis	
	5 15 22			−18·07		ρ Serpentis	
298	15 5 32 5	+0·44				η Ophiuchi	
		+0·65				ρ Serpentis	
	5 32 32			−28·07		η Ophiuchi	
				−12·30		ρ Serpentis	
301	18 4 52 11		+1·41				
	4 52 38				−24·29		
302	18 5 3 32	−0·12				η Ophiuchi	
	5 3 59			−17·46		η Ophiuchi	
303	18 5 12 8	−0·32				η Ophiuchi	
	5 12 36			− 9·40		η Ophiuchi	
304	18 5 21 16	+0·19				η Ophiuchi	
	5 21 43			−30·91		η Ophiuchi	
305	18 5 29 47	+0·69				η Ophiuchi	
	5 30 15			−36·56		η Ophiuchi	
	1836.						
308	Jan. 16 18 4 46	+6·49				c^2 Scorpii	
	18 4 57			+46·25	+13·58	c^2 Scorpii	
309	16 18 17 21	+2·73				c^2 Scorpii	
	18 17 35			+11·49	+ 8·51	c^2 Scorpii	
310	16 18 28 6	+5·23	a			c^2 Scorpii	
	18 28 13			− 9·33	+ 2·23	c^2 Scorpii	
312	27 18 4 55		+9·12				
	18 5 7				−59·65		

G. B. AIRY.

December 11, 1846.

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XIII. *The Longitude of the Observatory of Geneva deduced from Occultations of Fixed Stars. By Mr. Hugh Breen, Jun. of the Royal Observatory, Greenwich. Communicated by the Rev. R. Main.*

Read April 8, 1846.

The occultations on which these computations are founded are taken from *Observations Astronomiques faites à l'Observatoire de Genève dans les Ans* 1841, 1842, *et* 1843, par E. Plantamour, *Professeur d'Astronomie dans l'Université de Genève.*

The right ascension, north polar distance, horizontal parallax, and semi-diameter of the moon, have been interpolated, using second differences, from the *Nautical Almanac.* The right ascensions and north polar distances of the occulted stars have also been taken from the same work, and afterwards corrected, as described.

The form by which the resulting equations were computed was kindly supplied by the Astronomer Royal, and is applicable, whether the observations have been made in sidereal or mean solar time. The formulæ on which it depends are given in the introduction to the Greenwich Observations: they are,

$$\text{Seconds of } \frac{\theta-\theta'}{2} = \frac{\theta-\theta'}{\sin(\theta-\theta')} \times \frac{\cos l \sin \theta}{2 \sin \delta'} \times \frac{\sin P'}{P'} \times \text{seconds of } P'.$$

$$\text{Seconds of } \delta-\delta' = \frac{\delta-\delta'}{\sin(\delta-\delta')} \cdot \frac{\sin l \sin \delta \sin \theta}{\sin \frac{1}{2}(\theta+\theta') \cos \frac{1}{2}(\theta-\theta')} \cdot \frac{\sin P'}{P'} \times \text{seconds in } P'$$

$$-\frac{\delta-\delta'}{\sin(\delta-\delta')} \cdot \cot \tfrac{1}{2}(\theta+\theta') \sin(\delta+\delta') \frac{\tan \frac{1}{2}(\theta-\theta')}{\frac{1}{2}(\theta-\theta')} \times \text{seconds in } \tfrac{1}{2}(\theta-\theta').$$

In the above formulæ δ and θ are the north polar distance and the hour angle of the star, δ' and θ' those of the corresponding point of the moon's limb, as seen from the earth's centre, l the geocentric latitude of the place, and P'

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the horizontal parallax; and by assuming a value for δ' the equations are easily solved by approximation. Having assumed a longitude, and found the values of δ' and θ' corresponding to it, a second assumption has been made r^s west of the first, and the same quantities have been computed for it in like manner. Now let θ', δ', be the right ascension and north polar distance of the corresponding point; θ, δ, those of the moon's centre, and d_1 the distance between the centre and corresponding point; thus for the first assumption we have,

$$\cos d_1 = \cos\delta\cos\delta' + \sin\delta\sin\delta'\cos(\theta-\theta') \quad \ldots \quad (a),$$

or
$$d_1 = (\delta-\delta')\sec\psi,$$

where
$$\tan\psi = \frac{\sin\frac{1}{2}(\theta-\theta')}{\sin\frac{1}{2}(\delta-\delta')}\sqrt{\sin\delta\sin\delta'}.$$

Similarly a distance d_2 has been computed between the centre and the corresponding point for the second assumption of longitude. Having thus found d_1 and d_2, suppose the true longitude to be z^s west of that first assumed; then the distance between the centre and corresponding point for the true longitude will be represented by

$$d_1 + \frac{z(d_2-d_1)}{r}.$$

Suppose now the right ascension and north polar distance of the star to be increased by e'' and f'' respectively; the tabular right ascension and north polar distance of the moon's centre to be increased by x'' and y'' respectively; and the moon's tabular semidiameter to be increased by n''; then, since a change in the right ascension and north polar distance of the star produces very nearly the same change in the right ascension and north polar distance of the corresponding point, the effect of these changes on the distance will be found by differentiating the equation (a).

Thus, if only the right ascensions vary,

$$\delta d_1 = \frac{\sin\delta\sin\delta'(\theta-\theta')}{d_1}(x''-e'');$$

and if only the north polar distances vary,

$$\delta d_1 = \frac{\delta-\delta'}{d_1}(y''-f'').$$

Hence the final equation becomes,

$$d_1 + \frac{z(d_2-d_1)}{r} + \frac{\sin\delta\sin\delta'(\theta-\theta')}{d_1}(x''-e'') + \frac{\delta-\delta'}{d_1}(y''-f'') = \text{tab. semid.} + n''.$$

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From this equation we find the value of z, which, being applied to the first assumed longitude, gives the true longitude.

In accordance with a note in the Geneva Observations for 1842, the times noted by M. PLANTAMOUR have been increased by $0^s{\cdot}56$, except when the clock error has also been obtained by him; in this case, no correction has been applied.

A correction of $+2''{\cdot}35$ has been applied to the moon's semidiameter. (Greenwich Observations, 1843.)

The moon's horizontal parallax has also been increased by $\frac{1}{2600}$th part of the whole. (HENDERSON, *Mem. Ast. Soc.* vol. x.)

The corrections to be applied to the tabular right ascension and north polar distance of the moon have been taken from the Greenwich Meridian Observations nearest the time.

The corrections of the places of the stars are taken from the Greenwich Catalogue of 1439 stars; and for the stars not included in that catalogue, from the Catalogue of the British Association.

Year and Day.	Name of Star.	Phenom.	Equations for the Longitude of Geneva.		
1841.			m s		
July 30	σ Sagittarii	Im.	24 26·88 $+1{\cdot}813 \times (x-e)$	$-0{\cdot}284 \times (y-f)$	$+2{\cdot}029 \times n.$
Aug. 10	16 Pleiadum	Em.	24 46·67 $+1{\cdot}750$	$+0{\cdot}616$	$-2{\cdot}019$
	20 Pleiadum	Im.	24 47·91 $+1{\cdot}188$	$-2{\cdot}008$	$+2{\cdot}414$
	17 Pleiadum	Em.	24 53·12 $+1{\cdot}507$	$-0{\cdot}673$	$-1{\cdot}786$
	η Tauri	Im.	24 42·19 $+1{\cdot}897$	$+1{\cdot}244$	$+2{\cdot}426$
	24 Pleiadum	Em.	24 57·90 $+1{\cdot}195$	$-2{\cdot}316$	$-2{\cdot}662$
Sept. 9	ι Geminorum ..	Im.	24 43·82 $+1{\cdot}363$	$+1{\cdot}495$	$+2{\cdot}129$
	.....	Em.	24 50·42 $+1{\cdot}723$	$-1{\cdot}764$	$-2{\cdot}602$
Nov. 3	ω^1 Geminorum ..	Im.	24 30·41 $+2{\cdot}019$	$-2{\cdot}778$	$+3{\cdot}561$
	.....	Em.	25 10·04 $+1{\cdot}225$	$-2{\cdot}021$	$-2{\cdot}432$
1842.					
Mar. 22	o^2 Cancri	Im.	25 17·72 $+1{\cdot}391$	$+0{\cdot}839$	$+1{\cdot}678$
	.....	Em.	25 13·05 $+1{\cdot}399$	$+0{\cdot}782$	$-1{\cdot}656$
April 20	32 Sextantis	Im.	25 16·00 $+0{\cdot}962$	$+1{\cdot}869$	$+2{\cdot}105$
May 14	63 Geminorum ..	Im.	25 1·04 $+1{\cdot}288$	$+1{\cdot}662$	$+2{\cdot}169$
July 17	(237) Scorpii ..	Im.	24 41·30 $+1{\cdot}543$	$+1{\cdot}142$	$+2{\cdot}044$
Aug. 16	s Sagittarii	Im.	24 38·94 $+1{\cdot}888$	$+0{\cdot}623$	$+2{\cdot}162$
18	o^2 Capricorni ...	Im.	24 33·00 $+2{\cdot}424$	$+1{\cdot}257$	$+2{\cdot}845$
31	ζ Geminorum ..	Im.	24 37·04 $+1{\cdot}466 \times (x-e)$	$+0{\cdot}660 \times (y-f)$	$+1{\cdot}723 \times n.$

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Year and Day.	Name of Star.	Phenom.	Equations for the Longitude of Geneva.
1843. Mar. 11	Piazzi, vii. 144	Im.	$24^m\ 8^s\cdot21 + 1\cdot675 \times (x-e) + 0\cdot006 \times (y-f) + 1\cdot783 \times n.$
15	87 Leonis	Im.	$24\ 50\cdot52 + 1\cdot260 + 1\cdot016 + 1\cdot621$
	.....	Em.	$24\ 58\cdot35 + 1\cdot423 + 0\cdot644 - 1\cdot562$
April 12	B Virginis	Im.	$25\ 6\cdot19 + 0\cdot725 + 2\cdot319 + 2\cdot430$
Aug. 12	κ^2 Piscium	Im.	$24\ 33\cdot50 + 1\cdot548 - 1\cdot408 + 2\cdot092$
	.....	Em.	$24\ 46\cdot80 + 1\cdot912 - 0\cdot588 - 2\cdot000$
	κ^1 Piscium	Im.	$24\ 21\cdot99 + 0\cdot215 - 4\cdot526 + 4\cdot531$
17	τ^1 Arietis	Im.	$24\ 24\cdot55 + 1\cdot703 - 1\cdot089 + 2\cdot128$
	.....	Em.	$24\ 37\cdot83 + 1\cdot880 - 0\cdot178 - 2\cdot023$
Oct. 6	19 Piscium	Im.	$24\ 37\cdot95 + 1\cdot495 - 1\cdot605 + 2\cdot196$
	.....	Em.	$24\ 49\cdot84 + 1\cdot890 \times (x-e) - 0\cdot680 \times (y-f) - 2\cdot032 \times n.$

The following are the corrections of the moon's right ascension and north polar distance from the Greenwich Observations (x'' and y'' respectively):—

Year and Day.	Correction to Moon's Tabular R.A. from Naut. Alm.	Correction to Moon's Tabular N.P.D.	Year and Day.	Correction to Moon's Tabular R. A. from Naut. Alm.	Correction to Moon's Tabular N.P.D.
1841. July 30	+ 1″·35	+8″·07	1842. Aug. 30	−10″·20	−8″·29
Aug. 9	− 9·45	+6·39	1843. Mar. 15	(− 9·00)	(+0·14)
1842. Mar. 22	−13·20	−7·36	16	−10·65	+0·27
April 20	− 9·00	−9·60	April 12	− 8·25	−7·90
May 15	−13·35	−1·93	Aug. 12	− 6·90	+1·63
July 16	− 9·15	+0·43	17	(− 4·95)	(−0·97)
Aug. 16	+ 2·10	+4·39	18	− 4·50	−1·49
17	+ 6·60	+3·42	Oct. 5	− 2·40	+0·64
19	+ 2·55	+1·34	6	(−3·45)	(−0·39)

The numbers in parentheses have been assumed to be the errors of the moon's right ascension and north polar distance on the days on which there were no observations of the moon at Greenwich.

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Corrections of the Nautical Almanac Places of the Star's Right Ascension and North Polar Distance, deduced from the Greenwich Catalogue of 1439 *Stars, and the British Association Catalogue (e" and f" respectively).*

Year and Day.	Star's Name.	From Greenwich Catalogue.		From British Association Catalogue.		$x-e$	$y-f$
		Corr. to R. A.	Corr. to N. P. D.	Corr. to R. A.	Corr. to N. P. D.		
1841.							
July 30	σ Sagittarii ..	−1".65	+4".85	....	....	+ 3".00	+ 3".22
Aug. 10	16 Pleiadum ..	+0·30	+1·10	....	....	− 9·75	+ 5·29
	20 Pleiadum ..	−0·60	+0·44	....	....	− 8·85	+ 5·95
	17 Pleiadum ..	+2·25	−0·07	....	....	−11·70	+ 6·46
	η Tauri	−1·35	+1·55	....	....	− 8·10	+ 4·84
	24 Pleiadum ..	....	....	−4·50	− 0·68	− 4·95	+ 7·07
1842.							
Mar. 22	o^2 Cancri	+9·30	−2·43	....	....	−22·50	− 4·93
April 20	32 Sextantis ..	....	....	+5·70	+ 4·51	−14·70	−14·11
May 14	63 Geminorum	....	+2·27	−0·60	....	−12·75	− 4·20
July 17	(237) Scorpii .	....	....	+1·65	+ 6·25	−10·80	− 5·82
Aug. 16	s Sagittarii ..	....	....	+3·90	+13·70	− 1·80	− 9·31
18	o^2 Capricorni .	....	....	0·00	+ 8·39	+ 4·58	− 6·01
31	δ Geminorum	−2·25	−0·55	....	....	− 7·95	− 7·74
1843.							
Mar. 15	87 Leonis	−2·25	+1·65	....	....	− 6·75	− 1·51
April 12	B Virginis ..	....	....	+8·25	+ 5·39	−16·50	−13·29
Aug. 12	κ^2 Piscium ..	....	....	+3·60	+10·49	−10·50	− 8·86
	κ^1 Piscium ..	−2·55	+2·03	....	....	− 4·35	− 0·40
17	τ^1 Arietis	+0·30	+1·52	....	....	− 5·25	− 2·49
Oct. 6	19 Piscium ..	....	....	−0·45	− 0·50	− 3·00	+ 0·11

By substituting the values of $x-e$ and $y-f$, given in the foregoing table, in the corresponding equations for the longitude of Geneva, and taking $n = +2''{\cdot}35$, the following table is formed :—

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Year and Day.	Star's Name.	Phenomenon.	Resulting Longitude.
1841.			m s
July 30	σ Sagittarii ..	Immersion	24 36·17
Aug. 10	16 Pleiadum ..	Emersion	28·13
	20 Pleiadum ..	Immersion	31·12
	17 Pleiadum ..	Emersion	26·94
	η Tauri	Immersion	38·54
	24 Pleiadum ..	Emersion	29·20
1842.			
Mar. 22	o^2 Cancri	Immersion	46·22
	.....	Emersion	33·83
April 20	32 Sextantis ..	Immersion	40·44
May 14	63 Geminorum	Immersion	42·74
July 17	(237) Scorpii..	Immersion	(22·79)
Aug. 16	s Sagittarii ..	Immersion	34·82
18	o^2 Capricorni .	Immersion	37·01
31	ζ Geminorum	Immersion	24·33
1843.			
Mar. 15	87 Leonis	Immersion	44·29
	.....	Emersion	44·11
April 12	B Virginis ..	Immersion	29·13
Aug. 12	κ^2 Piscium ..	Immersion	34·61
	.....	Emersion	27·23
	κ^1 Piscium ..	Immersion	33·51
17	τ^1 Arietis	Immersion	23·32
	.....	Emersion	23·62
Oct. 6	19 Piscium ..	Immersion	38·44
	.....	Emersion	24 39·32

The mean of these (giving a weight of three observations to the stars on August 10, 1841) is $24^m\ 34^s{\cdot}64$, with a probable error of $\pm 1^s{\cdot}00$.

By taking the mean of those results for which the errors of the moon's place are given in the Greenwich Observations *on the day of occultation*, the deduced longitude (from nine results) is $24^m\ 35^s{\cdot}11$, with a probable error of $\pm 1^s{\cdot}2$.

HUGH BREEN, Jun.

Greenwich, March 12, 1846.

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XIV. *Account of some Circumstances historically connected with the Discovery of the Planet exterior to Uranus.* By G. B. Airy, Esq. Astronomer Royal.

Read November 13, 1846.

It has not been usual to admit into the *Memoirs* of this Society mere historical statements of circumstances which have occurred in our own times. I am not aware that this is a matter of positive regulation: it is, I believe, merely a rule of practice, of which the application in every particular instance has been determined by the discretion of those Officers of the Society with whom the arrangement of our *Memoirs* has principally rested. And there can be no doubt that the ordinary rule must be a rule for the exclusion of papers of this character; and that if a positive regulation is to be made, it must absolutely forbid the presentation of such histories. Yet it is conceivable that events may occur in which this rule ought to be relaxed; and such, I am persuaded, are the circumstances attending the discovery of the planet exterior to *Uranus*. In the whole history of astronomy, I had almost said in the whole history of science, there is nothing comparable to this. The history of the discoveries of new planets in the latter part of the last century, and in the present century, offers nothing analogous to it. *Uranus*, *Ceres*, and *Pallas*, were discovered in the course of researches which did not contemplate the possible discovery of planets. *Juno* and *Vesta* were discovered in following up a series of observations suggested by a theory which, fruitful as it has been, we may almost venture to call fanciful. *Astræa* was found in the course of a well-conducted re-examination of the heavens, apparently contemplating the discovery of a new planet as only one of many possible results. But the motions of *Uranus*, examined by philosophers who were fully impressed with the universality of the law of gravitation, have long

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exhibited the effects of some disturbing body: mathematicians have at length ventured on the task of ascertaining where such a body could be; they have pointed out that the supposition of a disturbing body moving in a certain orbit, precisely indicated by them, would entirely explain the observed disturbances of *Uranus:* they have expressed their conviction, with a firmness which I must characterise as wonderful, that the disturbing planet would be found exactly in a certain spot, and presenting exactly a certain appearance; and in that spot, and with that appearance, the planet has been found. Nothing in the whole history of astronomy can be compared with this.

The principal steps in the theoretical investigations have been made by one individual, and the published discovery of the planet was necessarily made by one individual. To these persons the public attention has been principally directed; and well do they deserve the honours which they have received, and which they will continue to receive. Yet we should do wrong if we considered that these two persons alone are to be regarded as the authors of the discovery of this planet. I am confident that it will be found that the discovery is a consequence of what may properly be called a movement of the age; that it has been urged by the feeling of the scientific world in general, and has been nearly perfected by the collateral, but independent labours, of various persons possessing the talents or powers best suited to the different parts of the researches.

With this conviction, it has appeared to me very desirable that the authentic history of this discovery should be published as soon as possible; not only because it will prove a valuable contribution to the history of science, but also because it may tend to do justice to some persons who otherwise would not receive in future times the credit which they deserve. And as a portion of the history, I venture to offer to this Society a statement of the circumstances which have come to my own knowledge. I have thought that I could with propriety do this: not because I can pretend to know all the history of the discovery, but because I know a considerable part of it; and because I can lay claim to the character of impartiality to this extent, that, though partaking of the general movement of the age, I have not directly contributed either to the theoretical or to the observing parts of the discovery. In a matter of this delicacy I have thought it best to act on my own judgment, without consulting any other person; I have, however, solicited the permission of my English correspondents for the publication of letters.

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Without pretending to fix upon a time when the conviction of the irreconcilability of the motions of *Uranus* with the law of gravitation first fixed itself in the minds of some individuals, we may without hesitation date the general belief in this irreconcilability from the publication of M. ALEXIS BOUVARD's *Tables of Uranus* in 1821. It was fully shewn in the introduction to the tables, that, when every correction for perturbation indicated by the best existing theories was applied, it was still impossible to reconcile the observations of FLAMSTEED, LEMONNIER, BRADLEY, and MAYER, with the orbit required by the observations made after 1781: and the elements of the orbit were adopted from the latter observations, leaving the discordances with the former (amounting sometimes to three minutes of arc) for future explanation.

The orbit thus adopted represented pretty well the observations made in the years immediately following the publication of the tables. But in five or six years the discordance again growing up became so great, that it could not escape notice. A small error was shewn by the Kremsmünster Observations of 1825 and 1826: but, perhaps, I am not in error in stating that the discordance was first prominently exhibited in the Cambridge Observations, the publication of which from 1828 was conducted under my superintendance.

While still residing at Cambridge, I received from the Rev. T. J. HUSSEY (now Dr. HUSSEY) a letter, of which the following is an extract. It will be considered, I think, as honourable to that gentleman's acuteness and zeal. I must premise that the writer had lately passed through Paris.

No. 1. *The Rev. T. J. HUSSEY to G. B. AIRY.*

[EXTRACT.]

"*Hayes, Kent. 17 November*, 1834.

"With M. ALEXIS BOUVARD I had some conversation upon a subject I had often meditated, which will probably interest you, and your opinion may determine mine. Having taken great pains last year with some observations of *Uranus*, I was led to examine closely BOUVARD's tables of that planet. The apparently inexplicable discrepancies between the ancient and modern observations suggested to me the possibility of some disturbing body beyond *Uranus*, not taken into account because unknown. My first idea was to ascertain some approximate place of this supposed body empirically, and then with my large reflector set to work to examine all the minute stars thereabouts; but I found myself totally inadequate to the former part of the

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task. If I could have done it formerly, it was beyond me now, even supposing I had the time, which was not the case. I therefore relinquished the matter altogether; but subsequently, in conversation with BOUVARD, I inquired if the above might not be the case: his answer was, that, as might have been expected, it had occurred to him, and some correspondence had taken place between HANSEN and himself respecting it. HANSEN's opinion was, that one disturbing body would not satisfy the phenomena; but that he conjectured there were two planets beyond *Uranus*. Upon my speaking of obtaining the places empirically, and then sweeping closely for the bodies, he fully acquiesced in the propriety of it, intimating that the previous calculations would be more laborious than difficult; that if he had leisure he would undertake them and transmit the results to me, as the basis of a very close and accurate sweep. I have not heard from him since on the subject, and have been too ill to write. What is your opinion on the subject? If you consider the idea as possible, can you give me the limits, roughly, between which this body or those bodies may probably be found during the ensuing winter? As we might expect an eccentricity [inclination?] approaching rather to that of the old planets than of the new, the breadth of the zone to be examined will be comparatively inconsiderable. I may be wrong, but I am disposed to think that, such is the perfection of my equatoreal's object-glass, I could distinguish, almost at once, the difference of light of a small planet and a star. My plan of proceeding, however, would be very different: I should accurately map the whole space within the required limits, down to the minutest star I could discern; the interval of a single week would then enable me to ascertain any change. If the whole of this matter do not appear to you a chimæra, which, until my conversation with BOUVARD, I was afraid it might, I shall be very glad of any sort of hint respecting it."

My answer was in the following terms:—

No. 2. *G. B. AIRY to the Rev. T. J. HUSSEY.*

[EXTRACT.]

"*Observatory, Cambridge*, 1834, *Nov.* 23.

"I have often thought of the irregularity of *Uranus*, and since the receipt of your letter have looked more carefully to it. It is a puzzling subject, but I give it as my opinion, without hesitation, that it is not yet in such a state

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as to give the smallest hope of making out the nature of any external action on the planet. FLAMSTEED's observations I reject (for the present) without ceremony: but the two observations by BRADLEY and MAYER cannot be rejected. Thus the state of things is this, — the mean motion and other elements derived from the observations between 1781 and 1825 give considerable errors in 1750, and give *nearly the same errors* in 1834, *when the planet is at nearly the same part of its orbit.* If the mean motion had been determined by 1750 and 1834, this would have indicated nothing; but the fact is, that the mean motions were determined (as I have said) independently. This does not look like irregular perturbation. The observations would be well reconciled if we could from theory bring in two terms; one a small error in BOUVARD's eccentricity and perihelion, the other a term depending on twice the longitude. The former, of course, we could do; of the latter there are two, viz. a term in the equation of the centre, and a term in the perturbations by *Saturn.* The first I have verified completely (formula and numbers); the second I have verified generally, but not completely: I shall, when I have an opportunity, look at it thoroughly. So much for my doubts as to the certainty of any extraneous action. But if it were certain that there were any extraneous action, I doubt much the possibility of determining the place of a planet which produced it. I am sure it could not be done till the nature of the irregularity was well determined from several successive revolutions."

It will readily be understood that I do not quote this letter as a testimony to my own sagacity; but I think it deserving of production, as shewing the struggle which was made twelve years ago to explain the motions of *Uranus,* and the difficulty which seemed to envelope the subject. With regard to my last sentence, I think it likely that the same difficulty would still have been felt, if the theorists who entered seriously upon the explanation of the perturbations had not trusted more confidently to BODE's law of distances than I did myself.

In the year 1836, having quitted the Observatory of Cambridge, I completed the reduction of the planetary observations made there during the years 1833, 1834, 1835, in such a form as to exhibit the heliocentric errors of the tabular places of *Uranus,* together with the effect of errors of the tabular radius vector. The memoir containing these reductions was subsequently

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printed in the *Memoirs* of this Society. The progress of the errors of the tables of *Uranus* was here clearly marked.

In 1837, I received from M. Eugène Bouvard a letter, from which I trust I may be permitted to make an extract. It will, I am certain, be received as creditable to the intelligence and industry of the astronomers of the Observatory of Paris.

No. 3. *M. Eugene Bouvard to G. B. Airy.*

[extract.]

"*Paris, ce 6 Octobre*, 1837.

"Dans le peu de moments de loisir que me laissent mes fonctions, je m'occupe d'un travail que je crois n'être pas sans importance. Mon oncle [M. Alexis Bouvard] travaille à refaire ses tables de *Jupiter* et de *Saturne*, en se servant des corrections apportées récemment aux élémens astronomiques. Il m'a cédé les tables d'*Uranus* à reconstruire. En consultant les comparaisons que vous avez fait des observations de cette planète avec les calculs des tables, on voit que les différences en latitude sont très-grandes et qu'elles vont toujours en augmentant. Cela tient-il à une perturbation inconnue apportée dans les mouvemens de cet astre par un corps situé au-delà ? Je ne sais, mais c'est du moins l'idée de mon oncle. Je regarde la solution de cette question comme fort importante. Mais, pour réussir, j'ai besoin de réduire les observations avec la plus grande précision, et souvent les moyens me manquent."

The remainder of this letter relates principally to the reduction of observations.

The following are extracts from my answer :—

No. 4. *G. B. Airy to M. Eugene Bouvard.*

[extract.]

"*Royal Observatory, Greenwich, October* 12, 1837.

"I think that, probably, you would gain much in the accuracy of the reduced observations by waiting a short time before you proceed with that part of your labour. Some time ago, I presented to the Astronomical Society of London a very complete reduction of the observations of all the planets made at Cambridge in the years 1833, 1834, 1835. This paper will, as I

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expect, very shortly be printed. I have reduced the observations made at Greenwich in 1836 in the same manner: the volume containing these reductions will very soon be published. * * * You may also know that I am engaged upon a general reduction of the observations of planets made at Greenwich, from the commencement of BRADLEY'S observations to the present time. It may, perhaps, be a year before I can furnish you with the places deduced from these observations. * * * With respect to the errors of the tables of *Uranus*, I think you will find that it is the *longitude* which is most defective, and that the errors in *latitude* are not at present increasing. To shew this, I set down a few of my results. * * * You will see by this statement that the errors of longitude are increasing with fearful rapidity, while those of latitude are nearly stationary. * * * I cannot conjecture what is the cause of these errors, but I am inclined, in the first instance, to ascribe them to some error in the perturbations. There is no error in the pure elliptic theory (as I found by examination some time ago). If it be the effect of any unseen body, it will be nearly impossible ever to find out its place."

On the 24th of February, 1838, I addressed a letter to M. SCHUMACHER, which is printed in the *Astronomische Nachrichten*, No. 349. In this letter it is shewn, by treatment of the results of the reduced observations of 1833, 1834, 1835, 1836 (to which allusion was made in my letter to M. EUGÈNE BOUVARD), that the tabular radius vector of *Uranus* was considerably too small. This deduction (which has been confirmed by the observations of all the subsequent years) has always appeared to me to be very important. It is, perhaps, worth while here to point out that the detection of this error arose, in the first place, from the circumstance that my observations of *Uranus* had not been confined to the mere opposition (as had too often been done), but had been extended, as far as possible, to quadratures; and, in the next place, from my having so reduced the observations as to exhibit the effect of error of the radius vector.

On the 14th of May, 1838, I transmitted to M. EUGÈNE BOUVARD the reduced observations of 1833, 1834, 1835, 1836; and referred him to the paper in the *Astronomische Nachrichten* which I have cited.

The following letter from EUGÈNE BOUVARD will shew how vigorously the attention of the astronomers of Paris was still directed to *Uranus*:—

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No. 5. *M. EUGÈNE BOUVARD to G. B. AIRY.*

[EXTRACT.]

"*Paris, ce 21 Mai*, 1844.

" * * * Je viens aujourd'hui vous prier de me communiquer, si c'est possible, les ascensions droites et les déclinaisons d'*Uranus* depuis 1781 jusqu'en 1800. * * * J'ai réduit moi-même toutes ces observations en m'en tenant aux élémens imprimés, mais je crains qu'il n'y ait quelques erreurs. Il y a surtout une telle incertitude sur les erreurs de collimation du quart de cercle depuis 1785 jusqu'en 1800, qu'il est presque impossible d'avoir une grande confiance dans les observations. * * * Mon travail est fort avancé. Je suis arrivé à des résultats fort bons déjà, puisque je satisfais aux observations actuelles et aux premières de 1781, 1782, &c., à 15″ de dégré près en longitude : tandisque d'après les tables de mon oncle les erreurs sont de près de 2′ de dégré actuellement. Si je mettais de côté les observations de MASKELYNE faites depuis 1785 jusqu'à 1796, mes tables pourraient satisfaire aux observations à 7″ ou 8″ près. Mais je crains que cette période ne m'empêche d'y parvenir ; et malheureusement c'est dans cette intervalle que les observations sont les plus défectueuses. * * * D'après mes calculs, il faut changer considérablement les élémens elliptiques d'HERSCHEL, surtout le moyen mouvement et le périhélie. J'ai déterminé aussi la masse de *Saturne*, et je la trouve très différente de celle que l'on admet ; il faut l'augmenter beaucoup. Mais j'attendrai une nouvelle approximation pour être tout à fait sûr de ma détermination."

After some further correspondence, I transmitted to M. EUGÈNE BOUVARD, on June 27, 1844, the proof-sheets of the *Planetary Reductions*, containing the right ascensions and north polar distances of *Uranus* ; and M. BOUVARD, in acknowledging the receipt of them, on July 1, 1844, pointed out an error in the refraction for June 15, 1819. I mention this to shew the extreme care with which M. E. BOUVARD's collateral calculations had been conducted.

Although no allusion is made in the last letter to the possible disturbing planet, it would be wrong to suppose that there was no thought of it. In fact, during the whole of these efforts for reforming the tables of *Uranus*, the dominant thought was, " Is it possible to explain the motions of *Uranus*, without admitting either a departure from the received law of attraction, or

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the existence of a disturbing planet?" I know not how far the extensive and accurate calculations of M. EUGÈNE BOUVARD may have been used in the subsequent French calculations, but I have no doubt whatever that the knowledge of the efforts of M. BOUVARD, the confidence in the accuracy of his calculations, and the perception of his failure to reconcile in a satisfactory way the theory and the observations, have tended greatly to impress upon astronomers, both French and English, the absolute necessity of seeking some external cause of disturbance.

I have departed from a strictly chronological order for the sake of keeping in connexion the papers which relate to the same trains of investigation. Several months before the date of the last letter quoted, I had received the first intimation of those calculations which have led to a distinct indication of the place where the disturbing planet ought to be sought. The date of the following letter is Feb. 13, 1844:—

No. 6. *Professor CHALLIS to G. B. AIRY.*

[EXTRACT.]

"*Cambridge Observatory, Feb.* 13, 1844.

"A young friend of mine, Mr. ADAMS, of St. John's College, is working at the theory of *Uranus*, and is desirous of obtaining errors of the tabular geocentric longitudes of this planet, when near opposition, in the years 1818–1826, with the factors for reducing them to errors of heliocentric longitude. Are your reductions of the planetary observations so far advanced that you could furnish these data? and is the request one which you have any objection to comply with? If Mr. ADAMS may be favoured in this respect, he is further desirous of knowing, whether in the calculation of the tabular errors any alterations have been made in BOUVARD's *Tables of Uranus* besides that of *Jupiter's* mass."

My answer was as follows:—

No. 7. *G. B. AIRY to Professor CHALLIS.*

[EXTRACT.]

"*Royal Observatory, Greenwich*, 1844, *Feb.* 15.

"I send all the results of the observations of *Uranus* made with both instruments [that is, the heliocentric errors of *Uranus* in longitude and latitude

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from 1754 to 1830, for all those days on which there were observations, both of right ascension and of polar distance]. No alteration is made in BOUVARD's *Tables of Uranus*, except increasing the two equations which depend on *Jupiter* by $\frac{1}{50}$ part. As constants have been added (in the printed tables) to make the equations positive, and as $\frac{1}{50}$ part of the numbers in the tables has been added, $\frac{1}{50}$ part of the constants has been subtracted from the final results."

Professor CHALLIS, in acknowledging the receipt of these, used the following expressions :—

No. 8. *Professor CHALLIS to G. B. AIRY.*

[EXTRACT.]

"*Cambridge Observatory, Feb.* 16, 1844.

"I am exceedingly obliged by your sending so complete a series of tabular errors of *Uranus*. * * * The list you have sent will give Mr. ADAMS the means of carrying on in the most effective manner the inquiry in which he is engaged."

The next letter shews that Mr. ADAMS had derived results from these errors.

No. 9. *Professor CHALLIS to G. B. AIRY.*

"*Cambridge Observatory, Sept.* 22, 1845.

"My friend Mr. ADAMS (who will probably deliver this note to you) has completed his calculations respecting the perturbation of the orbit of *Uranus* by a supposed ulterior planet, and has arrived at results which he would be glad to communicate to you personally, if you could spare him a few moments of your valuable time. His calculations are founded on the observations you were so good as to furnish him with some time ago; and from his character as a mathematician, and his practice in calculation, I should consider the deductions from his premises to be made in a trustworthy manner. If he should not have the good fortune to see you at Greenwich, he hopes to be allowed to write to you on this subject."

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On the day on which this letter was dated, I was present at a meeting of the French Institute. I acknowledged it by the following letter:—

No. 10. *G. B. Airy to Professor Challis.*

"*Royal Observatory, Greenwich, 1845, Sept. 29.*

"I was, I suppose, on my way from France, when Mr. Adams called here: at all events, I had not reached home, and therefore, to my regret, I have not seen him. Would you mention to Mr. Adams that I am very much interested with the subject of his investigations, and that I should be delighted to hear of them by letter from him?".

On one of the last days of October, 1845, Mr. Adams called at the Royal Observatory, Greenwich, in my absence, and left the following important paper:—

No. 11. *J. C. Adams, Esq. to G. B. Airy.*

"According to my calculations, the observed irregularities in the motion of *Uranus* may be accounted for by supposing the existence of an exterior planet, the mass and orbit of which are as follows:—

Mean Distance (assumed nearly in accordance with Bode's law)...	38·4
Mean Sidereal Motion in 365·25 days	1°30′·9
Mean Longitude, 1st October, 1845	323 34
Longitude of Perihelion	315 55
Eccentricity	0·1610
Mass (that of the sun being unity)	0·0001656.

For the modern observations I have used the method of normal places, taking the mean of the tabular errors, as given by observations near three consecutive oppositions, to correspond with the mean of the times; and the Greenwich Observations have been used down to 1830: since which, the Cambridge and Greenwich Observations, and those given in the *Astronomische Nachrichten*, have been made use of. The following are the remaining errors of mean longitude:—

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Observation — Theory.

1780	+0".27	1801	−0".04	1822	+0".30
1783	−0·23	1804	+1·76	1825	+1·92
1786	−0·96	1807	−0·21	1828	+2·25
1789	+1·82	1810	+0·56	1831	−1·06
1792	−0·91	1813	−0·94	1834	−1·44
1795	+0·09	1816	−0·31	1837	−1·62
1798	−0·99	1819	−2·00	1840	+1·73

The error for 1780 is concluded from that for 1781 given by observation, compared with those of four or five following years, and also with Lemonnier's observations in 1769 and 1771.

"For the ancient observations, the following are the remaining errors:—

Observation — Theory.

1690	+44".4	1750	−1".6	1763	− 5".1
1712	+ 6·7	1753	+5·7	1769	+ 0·6
1715	− 6·8	1756	−4·0	1771	+11·8

The errors are small, except for Flamsteed's observation of 1690. This being an isolated observation, very distant from the rest, I thought it best not to use it in forming the equations of condition. It is not improbable, however, that this error might be destroyed by a small change in the assumed mean motion of the planet."

I acknowledged the receipt of this paper in the following terms:—

No. 12. *G. B. Airy to J. C. Adams, Esq.*

"*Royal Observatory, Greenwich*, 1845, *Nov.* 5.

"I am very much obliged by the paper of results which you left here a few days since, shewing the perturbations on the place of *Uranus* produced by a planet with certain assumed elements. The latter numbers are all extremely satisfactory: I am not enough acquainted with Flamsteed's observations about 1690 to say whether they bear such an error, but I think it extremely probable.

"But I should be very glad to know whether this assumed perturbation will explain the error of the radius vector of *Uranus*. This error is now very

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considerable, as you will be able to ascertain by comparing the normal equations, given in the Greenwich observations for each year, for the times *before* opposition with the times *after* opposition."

I have before stated, that I considered the establishment of this error of the radius vector of *Uranus* to be a very important determination. I therefore considered that the trial, whether the error of radius vector would be explained by the same theory which explained the error of longitude, would be truly an *experimentum crucis*. And I waited with much anxiety for Mr. ADAMS's answer to my query. Had it been in the affirmative, I should at once have exerted all the influence which I might possess, either directly, or indirectly through my friend Professor CHALLIS, to procure the publication of Mr. ADAMS's theory.

From some cause with which I am unacquainted, probably an accidental one, I received no immediate answer to this inquiry. I regret this deeply, for many reasons.

While I was expecting more complete information on Mr. ADAMS's theory, the results of a new and most important investigation reached me from another quarter. In the *Compte Rendu* of the French Academy for the 10th of November, 1845, which arrived in this country in December, there is a paper by M. LE VERRIER on the perturbations of *Uranus* produced by *Jupiter* and *Saturn*, and on the errors in the elliptic elements of *Uranus*, consequent on the use of erroneous perturbations in the treatment of the observations. It is impossible for me here to enter into details as to the conclusions of this valuable memoir: I shall only say that, while the correctness of the former theories, as far as they went, was generally established, many small terms were added; that the accuracy of the calculations was established by duplicate investigations, following different courses, and executed with extraordinary labour; that the corrections to the elements, produced by treating the former observations with these corrected perturbations, were obtained; and that the correction to the ephemeris for the present time, produced by the introduction of the new perturbations and the new elements, was investigated, and found to be incapable of explaining the observed irregularity of *Uranus*. Perhaps it may be truly said that the theory of *Uranus* was now, for the first time, placed on a satisfactory foundation. This important

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labour, as M. Le Verrier states, was undertaken at the urgent request of M. Arago.

In the *Compte Rendu* for June 1, 1846, M. Le Verrier gave his second memoir on the theory of *Uranus*. The first part contains the results of a new reduction of nearly all the existing observations of *Uranus*, and their treatment with reference to the theory of perturbations, as amended in the former memoir. After concluding from this reduction that the observations are absolutely irreconcilable with the theory, M. Le Verrier considers in the second part all the possible explanations of the discordance, and concludes that none is admissible, except that of a disturbing planet exterior to *Uranus*. He then proceeds to investigate the elements of the orbit of such a planet, assuming that its mean distance is double that of *Uranus*, and that its orbit is in the plane of the ecliptic. The value of the mean distance, it is to be remarked, is not fixed entirely by Bode's law, although suggested by it; several considerations are stated which compel us to take a mean distance, not *very* greatly differing from that suggested by the law, but which nevertheless, without the suggestions of that law, would leave the mean distance in a most troublesome uncertainty. The peculiarity of the form which the investigation takes is then explained. Finally, M. Le Verrier gives as the most probable result of his investigations, that the true longitude of the disturbing planet for the beginning of 1847 must be about 325°, and that an error of 10° in this place is not probable. No elements of the orbit or mass of the planet are given.

This memoir reached me about the 23d or 24th of June. I cannot sufficiently express the feeling of delight and satisfaction which I received from it. The place which it assigned to the disturbing planet was the same, to one degree, as that given by Mr. Adams's calculations, which I had perused seven months earlier. To this time I had considered that there was still room for doubt of the accuracy of Mr. Adams's investigations; for I think that the results of algebraic and numerical computations, so long and so complicated as those of an inverse problem of perturbations, are liable to many risks of error in the details of the process: I know that there are important numerical errors in the *Mécanique Céleste* of Laplace; in the *Théorie de la Lune* of Plana; above all, in Bouvard's first tables of *Jupiter* and *Saturn*; and to express it in a word, I have always considered the cor-

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rectness of a distant mathematical result to be a subject rather of moral than of mathematical evidence. But now I felt no doubt of the accuracy of both calculations, as applied to the perturbation in longitude. I was, however, still desirous, as before, of learning whether the perturbation in radius vector was fully explained. I therefore addressed to M. LE VERRIER the following letter: —

No. 13. *G. B. AIRY to M. LE VERRIER.*

"*Royal Observatory, Greenwich, 1846, June 26.*

"I have read, with very great interest, the account of your investigations on the probable place of a planet disturbing the motions of *Uranus*, which is contained in the *Compte Rendu de l'Académie* of June 1; and I now beg leave to trouble you with the following question. It appears, from all the later observations of *Uranus* made at Greenwich (which are most completely reduced in the Greenwich observations of each year, so as to exhibit the effect of an error either in the tabular heliocentric longitude, or the tabular radius vector), that the tabular radius vector is considerably too small. And I wish to inquire of you whether this would be a consequence of the disturbance produced by an exterior planet, now in the position which you have indicated?

"I imagine that it would not be so, because the principal term of the inequality would probably be analogous to the moon's variation, or would depend on sin 2 $(v-v')$; and in that case the perturbation in radius vector would have the sign – for the present relative position of the planet and *Uranus*. But this analogy is worth little, until it is supported by proper symbolical computations.

"By the earliest opportunity I shall have the honour of transmitting to you a copy of the *Planetary Reductions*, in which you will find all the observations made at Greenwich to 1830 carefully reduced and compared with the tables.

Before I could receive M. LE VERRIER'S answer, a transaction occurred which had some influence on the conduct of English astronomers.

On the 29th of June, a meeting of the Board of Visitors of the Royal Observatory of Greenwich was held, for the consideration of special business. At this meeting, Sir J. HERSCHEL and Professor CHALLIS (among other

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members of the Board) were present; I was also present, by invitation of the Board. The discussion led, incidentally, to the general question of the advantage of distributing subjects of observation among different observatories. I spoke strongly in favour of such distribution; and I produced, as an instance, the extreme probability of now discovering a new planet in a very short time, provided the powers of one observatory could be directed to the search for it. I gave, as the reason upon which this probability was based, the very close coincidence between the results of Mr. ADAMS's and M. Le VERRIER's investigations of the place of the supposed planet disturbing *Uranus*. I am authorised by Sir J. HERSCHEL's printed statement in the *Athenæum* of October 3, to ascribe to the strong expressions which I then used the remarkable sentence in Sir J. HERSCHEL's address, on September 10, to the British Association assembled at Southampton. "We see it [the probable new planet] as Columbus saw America from the shores of Spain. Its movements have been felt, trembling along the far-reaching line of our analysis, with a certainty hardly inferior to that of ocular demonstration."* And I am authorised by Professor CHALLIS, in oral conversation, to state that the same expressions of mine induced him to contemplate the search for the suspected planet.

M. LE VERRIER's answer reached me, I believe, on the 1st of July. The following are extracts from it:—

No. 14. *M. LE VERRIER to G. B. AIRY.*

[EXTRACT.]

"*Paris*, 28 *Juin*, 1846.

"* * * Il a toujours été dans mon désir de vous en écrire, aussi qu'à votre savante Société. Mais j'attendais, pour cela, que mes recherches fussent complètes, et ainsi moins indignes de vous être offertes. Je compte avoir terminé la rectification des élémens de la planète troublante avant l'opposition qui va arriver; et parvenir à connaître ainsi les positions du nouvel astre avec une grande précision. Si je pouvais espérer que vous aurez assez de confiance dans mon travail pour chercher cette planète dans le ciel,

* This sentence is copied from the written draft of the speech. Sir J. HERSCHEL appeared to suppose that the sentence had not been reported in the public journals as spoken. I did, however, see it so reported in an English newspaper, to which I had access on the Continent.

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je m'empresserais, Monsieur, de vous envoyer sa position exacte, dès que je l'aurai obtenue.

" La comparaison des positions d'*Uranus*, observées dans ces dernières années, dans les oppositions et dans les quadratures, montre que le rayon de la planète, calculé par les tables en usage, est effectivement très-inexact. Cela n'a pas lieu dans mon orbite, telle que je l'ai déterminée; il n'y a pas plus d'erreur dans les quadratures que dans les oppositions.

" Le rayon est donc bien calculé dans mon orbite; et, si je ne me trompe, M. AIRY désirerait savoir quelle est la nature de la correction que j'ai fait subir à cet égard aux tables en usage?

" Vous avez raison, Monsieur, de penser que cette correction n'est pas due à la perturbation du rayon vecteur produite *actuellement* par la planète troublante. Pour s'en rendre un compte exact, il faut remarquer que l'orbite d'*Uranus* a été calculée par M. BOUVARD sur des positions de la planète qui n'étaient pas *les positions elliptiques*, puisqu'on n'avait pas pu avoir égard aux perturbations produites par la planète inconnue. Cette circonstance a nécessairement rendu les élémens de l'ellipse faux, et c'est à l'erreur de l'excentricité et à l'erreur de la longitude du périhélie qu'il faut attribuer l'erreur actuelle du rayon vecteur d'*Uranus*.

" Il résulte de ma théorie que l'excentricité donnée par M. BOUVARD doit être augmentée, et qu'il en est de même de la longitude du périhélie; deux causes qui contribuent, à cause de la position actuelle de la planète dans son orbite, à augmenter le rayon vecteur. Je ne transcris pas ici les valeurs de ces accroissemens, parceque je ne les ai pas encore avec toute la rigueur précise, mais je les aurai rectifié avant un mois, et je me ferai un devoir, Monsieur, de vous les transmettre aussitôt, si cela vous est agréable.

" Je me bornerai à ajouter que la position en quadrature, déduite en 1844 des deux oppositions qui la comprennent, au moyen de mes formules, ne diffère de la position observée que de $0''{\cdot}6$; ce qui prouve que l'erreur du rayon vecteur est entièrement disparue.

" C'est même une des considérations qui devront donner plus de probabilité à la vérité de mes résultats, qu'ils rendent un compte scrupuleux de toutes les circonstances du problème. Ainsi, bien que je n'aye fait usage dans mes premières recherches que des oppositions, les quadratures n'ont pas laissé de se trouver calculées avec toute l'exactitude possible. Le rayon vecteur s'est trouvé rectifié de lui-même, sans que l'on l'eut pris en considération

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d'une manière directe. Excusez-moi, Monsieur, d'insister sur ce point. C'est une suite du désir que j'ai d'obtenir votre suffrage.

"Je recevrai avec bien du plaisir les observations que vous voulez bien m'annoncer. Malheureusement le temps presse; l'opposition approche; il faut de toute necessité que j'aye fini pour cette époque. Je ne pourrai donc pas comprendre ces observations dans mon travail. Mais elles me seront très-utiles pour me servir de vérifications; et c'est ce à quoi je les employerai certainement."

It is impossible, I think, to read this letter without being struck with its clearness of explanation, with the writer's extraordinary command, not only of the physical theories of perturbation but also of the geometrical theories of the deduction of orbits from observation, and with his perception that his theory *ought* to explain all the phenomena, and his firm belief that it *had* done so. I had now no longer any doubt upon the reality and general exactness of the prediction of the planet's place. My approaching departure for the Continent made it useless for me to trouble M. LE VERRIER with a request for the more accurate numbers to which he alludes; but the following correspondence will shew how deeply his remarks had penetrated my mind.

About a week after the receipt of M. LE VERRIER's letter, while on a visit to my friend the Dean of Ely, I wrote to Professor CHALLIS as follows:—

No. 15. *G. B. AIRY to Professor CHALLIS.*

"*The Deanery, Ely*, 1846, *July* 9.

"You know that I attach importance to the examination of that part of the heavens in which there is * * * * reason for suspecting the existence of a planet exterior to *Uranus*. I have thought about the way of making such examination, but I am convinced that (for various reasons, of declination, latitude of place, feebleness of light, and regularity of superintendence), there is no prospect whatever of its being made with any chance of success, except with the Northumberland telescope.

"Now I should be glad to ask you, in the first place, whether you could make such an examination?

"Presuming that your answer would be in the negative, I would ask, se-

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condly, whether, supposing that an assistant were supplied to you for this purpose, you would superintend the examination?

"You will readily perceive that all this is in a most unformed state at present, and that I am asking these questions almost at a venture, in the hope of rescuing the matter from a state which is, without the assistance that you and your instruments can give, almost desperate. Therefore I should be glad to have your answer, not only responding simply to my questions, but also entering into any other considerations which you think likely to bear on the matter.

"The time for the said examination is approaching near."

In explanation of this letter, it may be necessary to state that, in common, I believe, with other astronomers at that time, I thought it likely that the planet would be visible only in large telescopes. I knew that the Observatory of Cambridge was at this time oppressed with work, and I thought that the undertaking—a survey of such an extent as this seemed likely to prove—would be entirely beyond the powers of its personal establishment. Had Professor CHALLIS assented to my proposal of assistance, I was prepared immediately to place at his disposal the services of an efficient assistant; and for approval of such a step, and for liquidation of the expense which must thus be thrown on the Royal Observatory, I should have referred to a Government which I have never known to be illiberal when demands for the benefit of science were made by persons whose character and position offered a guarantee, that the assistance was fairly asked for science, and that the money would be managed with fair frugality. In the very improbable event of the Government refusing such indemnity, I was prepared to take all consequences on myself.

On the 13th of July, I transmitted to Professor CHALLIS "Suggestions for the Examination of a Portion of the Heavens in search of the external Planet which is presumed to exist and to produce disturbance in the motion of *Uranus*," and I accompanied them with the following letter:—

No. 16. *G. B. AIRY to Professor CHALLIS.*

"*Royal Observatory, Greenwich*, 1846, *July* 13.

"I have drawn up the enclosed paper in order to give you a notion of the extent of work incidental to a sweep for the possible planet.

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"I only add at present that, in my opinion, the importance of this inquiry exceeds that of any current work, which is of such a nature as not to be totally lost by delay."

My "Suggestions" contemplated the examination of a part of the heavens 30° long, in the direction of the ecliptic, and 10° broad. They entered into considerable details as to the methods which I proposed; details which were necessary in order to form an estimate of the number of hours' work likely to be employed in the sweep.

I received, in a few days, the following answer:—

No. 17. *Professor CHALLIS to G. B. AIRY.*

[EXTRACTS.]

"*Cambridge Observatory, July* 18, 1846.

"I have only just returned from my excursion. * * * I have determined on sweeping for this hypothetical planet. * * * With respect to your proposal of supplying an assistant I need not say any thing, as I understand it to be made on the supposition that I decline undertaking the search myself. * * * I purpose to carry the sweep to the extent you recommend."

The remainder of the letter was principally occupied with the details of a plan of observing different from mine, and of which the advantage was fully proved in the practical observation.

On August 7, Professor CHALLIS, writing to my confidential assistant (Mr. MAIN) in my supposed absence, said,—

No. 18. *Professor CHALLIS to the Rev. R. MAIN.*

[EXTRACT.]

"*Cambridge Observatory, August* 7, 1846.

"I have undertaken to search for the supposed new planet more distant than *Uranus*. Already I have made trial of two different methods of observing. In one method, recommended by Mr. AIRY * * * I met with a difficulty which I had anticipated. * * * I adopted a second method."

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From a subsequent letter (to be cited hereafter), it appears that Professor CHALLIS had commenced the search on July 29, and had actually observed the planet on August 4, 1846.

Mr. MAIN's answer to the other parts of this letter, written by my direction, is dated August 8.

At Wiesbaden (which place I left on September 7), I received the following letter from Professor CHALLIS:—

No. 19. *Professor CHALLIS to G. B. AIRY.*

[EXTRACT.]

"*Cambridge Observatory, Sept.* 2, 1846.

"I have lost no opportunity of searching for the planet; and, the nights having been generally pretty good, I have taken a considerable number of observations: but I get over the ground very slowly, thinking it right to include all stars to 10–11 magnitude; and I find, that to scrutinise thoroughly in this way the proposed portion of the heavens will require many more observations than I can take this year."

On the same day on which Professor CHALLIS wrote this letter, Mr. ADAMS, who was not aware of my absence from England, addressed the following very important letter to Greenwich:—

No. 20. *J. C. ADAMS, Esq. to G. B. AIRY.*

"*St. John's College, Cambridge, Sept.* 2, 1846.

"In the investigation, the results of which I communicated to you last October, the mean distance of the supposed disturbing planet is assumed to be twice that of *Uranus*. Some assumption is necessary in the first instance, and BODE's law renders it probable that the above distance is not very remote from the truth: but the investigation could scarcely be considered satisfactory while based on any thing arbitrary; and I therefore determined to repeat the calculation, making a different hypothesis as to the mean distance. The eccentricity also resulting from my former calculations was far too large to be probable; and I found that, although the agreement between theory and observation continued very satisfactory down to 1840, the difference in subsequent years was becoming very sensible, and I hoped that these errors, as well as the eccentricity, might be diminished by taking a different mean distance. Not to make too violent a change, I assumed this distance to be

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less than the former value by about $\frac{1}{30}$th part of the whole. The result is very satisfactory, and appears to shew that, by still further diminishing the distance, the agreement between the theory and the later observations may be rendered complete, and the eccentricity reduced at the same time to a very small quantity. The mass and the elements of the orbit of the supposed planet, which result from the two hypotheses, are as follows:—

	Hypothesis I. $\left(\frac{a}{a^1} = 0{\cdot}5\right)$	Hypothesis II. $\left(\frac{a}{a^1} = 0{\cdot}515\right)$
Mean Longitude of Planet, 1st October, 1846 ..	325° 8′	323° 2′
Longitude of Perihelion	315 57	299 11
Eccentricity	0·16103	0·12062
Mass (that of Sun being 1)	0·00016563	0·00015003

"The investigation has been conducted in the same manner in both cases, so that the differences between the two sets of elements may be considered as wholly due to the variation of the fundamental hypothesis. The following table exhibits the differences between the theory and the observations which were used as the basis of calculation. The quantities given are the errors of *mean* longitude, which I found it more convenient to employ in my investigations than those of the true longitude.

Ancient Observations.

Date.	(Obs.—Theory.) Hypoth. I.	Hypoth. II.	Date.	(Obs.—Theory.) Hypoth. I.	Hypoth II.
1712	+6″·7	+6″·3	1756	− 4″·0	− 4″·0
1715	−6·8	−6·6	1764	− 5·1	− 4·1
1750	−1·6	−2·6	1769	+ 0·6	+ 1·8
1753	+5·7	+5·2	1771	+11·8	+12·8

Modern Observations.

1780	+0″·27	+0″·54	1810	+0″·56	+0″·61
1783	−0·23	−0·21	1813	−0·94	−1·00
1786	−0·96	−1·10	1816	−0·31	−0·46
1789	+1·82	+1·63	1819	−2·00	−2·19
1792	−0·91	−1·06	1822	+0·30	+0·14
1795	+0·09	+0·04	1825	+1·92	+1·87
1798	−0·99	−0·93	1828	+2·25	+2·35
1801	−0·04	+0·11	1831	−1·06	−0·82
1804	+1·76	+1·94	1834	−1·44	−1·17
1807	−0·21	−0·08	1837	−1·62	−1·53
1810	+0·56	+0·61	1840	+1·73	+1·31

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"The greatest difference in the above table, viz. that for 1771, is deduced from a single observation, whereas the difference immediately preceding, which is deduced from the mean of several observations, is much smaller. The error of the tables for 1780 is found by interpolating between the errors given by the observations of 1781, 1782, and 1783, and those of 1769 and 1771. The differences between the results of the two hypotheses are exceedingly small till we come to the last years of the series, and become sensible precisely at the point where both sets of results begin to diverge from the observations; the errors corresponding to the second hypothesis being, however, uniformly smaller. The errors given by the Greenwich Observations of 1843 are very sensible, being for the first hypothesis $+6''\cdot84$, and for the second $+5''\cdot50$. By comparing these errors, it may be inferred that the agreement of theory and observation would be rendered very close by assuming $\frac{a}{a^1} = 0\cdot57$, and the corresponding mean longitude on 1st October, 1846, would be about $315^\circ\ 20'$, which I am inclined to think is not far from the truth. It is plain, also, that the eccentricity corresponding to this value of $\frac{a}{a^1}$ would be very small. In consequence of the divergence of the results of the two hypotheses, still later observations would be most valuable for correcting the distances, and I should feel exceedingly obliged if you would kindly communicate to me two normal places near the oppositions of 1844 and 1845.

"As Flamsteed's first observation of *Uranus* (in 1690) is a single one, and the interval between it and the rest is so large, I thought it unsafe to employ this observation in forming the equations of condition. On comparing it with the theory, I find the difference to be rather large, and greater for the second hypothesis than for the first, the errors being $+44''\cdot5$ and $+50''\cdot0$ respectively. If the error be supposed to change in proportion to the change of mean distance, its value corresponding to $\frac{a}{a^1} = 0\cdot57$ will be about $+70''$, and the error in the time of transit will be between 4^s and 5^s. It would be desirable to ascertain whether Flamsteed's manuscripts throw any light on this point.

"The corrections of the tabular radius vector of *Uranus*, given by the theory for some late years, are as follows:—

Date.	Hypoth. I.	Hypoth. II.
1834	+0·005051	+0·004923
1840	+0·007219	+0·006962
1846	+0·008676	+0·008250

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"The correction for 1834 is very nearly the same as that which you have deduced from observation, in the *Astronomische Nachrichten;* but the increase in later years is more rapid than the observations appear to give it: the second hypothesis, however, still having the advantage.

"I am at present employed in discussing the errors in latitude, with the view of obtaining an approximate value of the inclination and position of the node of the new planet's orbit; but the perturbations in latitude are so very small that I am afraid the result will not have great weight. According to a rough calculation made some time since, the inclination appeared to be rather large, and the longitude of the ascending node to be about 300°; but I am treating the subject much more completely, and hope to obtain the result now in a few days.

"I have been thinking of drawing up a brief account of my investigation to present to the British Association."

Mr. MAIN, acting for the Astronomer Royal in his absence, answered this letter as follows:—

No. 21. *The Rev. R. MAIN to J. C. ADAMS, Esq.*

"*Royal Observatory, Greenwich, 1846, Sept. 5.*

"The Astronomer Royal is not at home, and he will be absent for some time; but it appears to me of so much importance that you should have immediately the normal errors of *Uranus* for 1844 and 1845, that I herewith send you the former (the volume for 1844 has been published for some time), and I shall probably be able to send you those for 1845 on Tuesday next, as I have given directions to have the computations finished immediately. If a place (geocentric) for the present year should be of value to you, I could probably send one in a few days."

In acknowledging this letter, Mr. ADAMS used the following expression:—

No. 22. *J. C. ADAMS, Esq. to the Rev. R. MAIN.*

[EXTRACT.]

"*St. John's College, Cambridge, 7th Sept. 1846.*

"I hope by to-morrow to have obtained approximate values of the inclination and longitude of the node."

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On the same day, Sept. 7, Mr. MAIN transmitted to Mr. ADAMS the normal places for 1845, to which allusion was made in the letter of Sept. 5.

On the 31st of August, M. LE VERRIER'S second paper on the place of the disturbing planet (the third paper on the motion of *Uranus*) was communicated to the French Academy. I place the notice of this paper after those of September 2, &c., because, in the usual course of transmission to this country, the number of the *Comptes Rendus* containing this paper would not arrive here, at the earliest, before the third or fourth week in September; and it does not appear that any earlier notice of its contents was received in England.

It is not my design here to give a complete analysis of this remarkable paper; but I may advert to some of its principal points. M. LE VERRIER states that, considering the extreme difficulty of attempting to solve the problem in all its generality, and considering that the mean distance and the epoch of the disturbing planet were determined approximately by his former investigations, he adopted the corrections to these elements as two of the unknown quantities to be investigated. Besides these, there are the planet's mass, and two quantities from which the eccentricity and the longitude of perihelion may be inferred; making, in all, five unknown quantities depending solely on the orbit and mass of the disturbing planet. Then there are the possible corrections to the mean distance of *Uranus*, to its epoch of longitude, to its longitude of perihelion, and to its eccentricity; making, in all, nine unknown quantities. To obtain these, M. LE VERRIER groups all the observations into thirty-three equations. He then explains the peculiar method by which he derives the values of the unknown quantities from these equations. The elements obtained are,—

Semi-axis Major	$36{\cdot}154$ $\left(\text{or } \frac{a}{a^1} = 0{\cdot}531\right)$
Periodic Time	$217^{y}{\cdot}387$
Eccentricity	$0{\cdot}10761$
Longitude of Perihelion	$284^{\circ}\ 45'$
Mean Longitude, 1 Jan. 1847.....	$318\ \ 47$

$$\text{Mass } \frac{1}{9300} = 0{\cdot}0001075$$

True Heliocentric Longitude, 1 Jan. 1847 ...	$326^{\circ}\ 32'$
Distance from the Sun	$33{\cdot}06$

It is interesting to compare these elements with those obtained by Mr. ADAMS. The difference between each of these and the corresponding

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element obtained by Mr. ADAMS in his second hypothesis is, in every instance, of that kind which corresponds to the further change in the assumed mean distance recommended by Mr. ADAMS. The agreement with observations does not appear to be better than that obtained from Mr. ADAMS's elements, with the exception of FLAMSTEED's first observation of 1690, for which (contrary to Mr. ADAMS's expectation) the discordance is considerably diminished.

M. LE VERRIER then enters into a most ingenious computation of the limits between which the planet must be sought. The principle is this: assuming a time of revolution, all the other unknown quantities may be varied in such a manner, that though the observations will not be so well represented as before, yet the errors of observation will be tolerable. At last, on continuing the variation of elements, one error of observation will be intolerably great. Then, by varying the elements in another way, we may at length make another error of observation intolerably great: and so on. If we compute, for all these different varieties of elements, the place of the planet for 1847, its *locus* will evidently be a discontinuous curve or curvilinear polygon. If we do the same thing with different periodic times, we shall get different polygons; and the extreme periodic times that can be allowed will be indicated by the polygons becoming points. These extreme periodic times are 207 and 233 years. If now we draw one grand curve, circumscribing all the polygons, it is certain that the planet must be within that curve. In one direction, M. LE VERRIER found no difficulty in assigning a limit; in the other he was obliged to restrict it, by assuming a limit to the eccentricity. Thus he found that the longitude of the planet was certainly not less than 321°, and not greater than 335° or 345°, according as we limit the eccentricity to 0·125 or 0·2. And if we adopt 0·125 as the limit, then the mass will be included between the limits 0·00007 and 0·00021; either of which exceeds that of *Uranus*. From this circumstance, combined with a probable hypothesis as to the density, M. LE VERRIER concluded that the planet would have a visible disk, and sufficient light to make it conspicuous in ordinary telescopes.

M. LE VERRIER then remarks, as one of the strong proofs of the correctness of the general theory, that the error of radius vector is explained as accurately as the error of longitude. And finally, he gives his opinion that the latitude of the disturbing planet must be small.

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My analysis of this paper has necessarily been exceedingly imperfect, as regards the astronomical and mathematical parts of it; but I am sensible that, in regard to another part, it fails totally. I cannot attempt to convey to you the impression which was made on me by the author's undoubting confidence in the general truth of his theory, by the calmness and clearness with which he limited the field of observation, and by the firmness with which he proclaimed to observing astronomers, "Look in the place which I have indicated, and you will see the planet well." Since COPERNICUS* declared that, when means should be discovered for improving the vision, it would be found that *Venus* had phases like the moon, nothing (in my opinion) so bold, and so justifiably bold, has been uttered in astronomical prediction. It is here, if I mistake not, that we see a character far superior to that of the able, or enterprising, or industrious mathematician; it is here that we see the philosopher. The mathematical investigations will doubtless be published in detail; and they will, as mathematical studies, be highly instructive: but no details published after the planet's discovery can ever have for me the charm which I have found in this abstract which preceded the discovery.

I understand that M. LE VERRIER communicated his principal conclusions to the astronomers of the Berlin Observatory on September 23, and that, guided by them, and comparing their observations with a star-map, they found the planet on the same evening. And I am warranted by the verbal assurances of Professor CHALLIS in stating that, having received the paper on September 29, he was so much impressed with the sagacity and clearness of M. LE VERRIER'S limitations of the field of observation, that he instantly changed his plan of observing, and noted the planet, as an object having a visible disk, on the evening of the same day.

My account, as a documentary history, supported by letters written during the events, is properly terminated; but I think it advisable, for the sake of clearness, to annex extracts from a letter which I have received from Professor CHALLIS since the beginning of October, when I returned to England.

* I borrow this history from SMITH'S *Optics*, sect. 1050. Since reading this memoir, I have, however, been informed by Professor DE MORGAN, that the printed works of COPERNICUS do not at all support this history, and that COPERNICUS appears to have believed that the planets are self-luminous.— G. B. A. [See Professor DE MORGAN'S paper in the *Monthly Notice* of the Royal Astronomical Society for June 1847.— SEC.]

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No. 23. *Professor CHALLIS to G. B. AIRY.*

[EXTRACT.]

"*Cambridge Observatory, October* 12, 1846.

"I had heard of the discovery [of the new planet] on October 1. * * * I find that my observations would have shewn me the planet in the early part of August, if I had only discussed them. I commenced observing on July 29, attacking first of all, as it was prudent to do, the position which Mr. ADAMS's calculations assigned as the most probable place of the planet. On July 30, I adopted the method of observing which I spoke of to you. * * * In this way I took all the stars to the 11th magnitude in a zone of 9′ in breadth, and was sure that none brighter than the 11th escaped me. My next observations were on August 4. On this day * * * I took stars here and there in a zone of about 70′ in breadth, purposely selecting the brighter, as I intended to make them reference-points for the observations in zones of 9′ breadth. Among these stars was the planet. A comparison of this day's observations with a good star-map would most probably have detected it. On account of moonlight I did not observe again till August 12. On that day I went over again the zone of 9′ breadth which I examined on July 30. * * * The space gone over on August 12, exceeded in length that of July 30, but included the whole of it. On comparing [at a later time] the observations of these two days, I found that the zone of July 30 contained *every* star in the corresponding portion of the zone of August 12, *except one star of the 8th magnitude.* This, according to the principle of search, which in the want of a good star-map I had adopted, must have been a planet. It had wandered into the latter zone in the interval between July 30 and August 12. By this statement you will see, that, after four days of observing, the planet was in my grasp, if only I had examined or mapped the observations. I delayed doing this, partly because I thought the probability of discovery was small till a much larger portion of the heavens was scrutinised, but chiefly because I was making a grand effort to reduce the vast number of comet observations which I have accumulated: and this occupied the whole of my time when I was not engaged in observing. I actually compared to a certain extent the observations of July 30 and August 12, soon after taking them, more for the sake of testing the two methods of observing adopted on those days than for any other purpose; and

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I stopped short within a very few stars of the planet. After August 12, I continued my observations with great diligence, recording the positions of, I believe, some thousands of stars: but I did not again fall in with the planet, as I took positions too early in right ascension. * * * On Sept. 29, however, I saw, for the first time, Le Verrier's last results, and on the evening of that day I observed strictly according to his suggestions, and within the limits he recommended; and I was also on the look-out for a disk. Among 300 stars which I took that night, I singled out one, against which I directed my assistant to note "seems to have a disk," which proved to be the planet. I used on this, as on all other occasions, a power of 160. This was the third time I obtained an approximate place of the planet before I heard of its discovery."

This letter was written to me purely as a private communication, but I have received permission from Professor Challis to publish it with the rest.

Before terminating this account, I beg leave to present the following remarks:—

First. It would not be just to institute a comparison between papers which at this time exist only in manuscript, and papers which have been printed by their authors; the latter being in all cases more complete and more elaborately worked out than the former.

Second. I trust that I am amply supported, by the documentary history which I have produced, in the view which I first took, namely, that the discovery of this new planet is the effect of a movement of the age. It is shewn, not merely by the circumstance that different mathematicians have simultaneously but independently been carrying on the same investigations, and that different astronomers, acting without concert, have at the same time been looking for the planet in the same part of the heavens; but also by the circumstance that the minds of these philosophers, and of the persons about them, had long been influenced by the knowledge of what had been done by others, and of what had yet been left untried; and that in all parts of the work the mathematician and the astronomer were supported by the exhortations and the sympathy of those whose opinions they valued most. I do not consider this as detracting in the smallest degree from the merits of the persons who have been actually engaged in these investigations.

Third. This history presents a remarkable instance of the importance, in

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doubtful cases, of using any received theory as far as it will go, even if that theory can claim no higher merit than that of being plausible. If the mathematicians whose labours I have described had not adopted BODE's law of distances (a law for which no physical theory of the rudest kind has ever been suggested), they would never have arrived at the elements of the orbit. At the same time, this assumption of the law is only an aid to calculation, and does not at all compel the computer to confine himself perpetually to the condition assigned by this law, as will have been remarked in the ultimate change of mean distance made by both the mathematicians, who have used BODE's law to give the first approximation to mean distance.

Fourth. The history of this discovery shews that, in certain cases, it is advantageous for the progress of science that the publication of theories, when so far matured as to leave no doubt of their general accuracy, should not be delayed till they are worked to the highest imaginable perfection. It appears to be quite within probability, that a publication of the elements obtained in October 1845 might have led to the discovery of the planet in November 1845.

I have now only to request the indulgence of my readers for the apparently egoistical character of the account which I have here given; a character which it is extremely difficult to remove from a history that is almost strictly confined to transactions with which I have myself been concerned.

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XV. *An Account of Observations undertaken in search of the Planet discovered at Berlin on Sept. 23, 1846. By the Rev. James Challis, M.A. F.R.A.S. Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge.*

Read Nov. 13, 1846.

Although the observations I am about to give an account of did not result in announcing the discovery of a new planet, I think that the history of them may yet be read with some degree of interest. I believe I shall be correct in saying that no systematic operations in search of the planet recently discovered by Dr. Galle, at Berlin, were undertaken in any European observatory at the same period, and to the same extent, as in that of Cambridge. I believe also that the history of astronomical science does not afford a parallel instance of an astronomer entering upon what might reasonably have been expected to be a long and laborious search, entirely in reliance upon deductions from theoretical calculations. For these reasons, and because I am able to shew that the observations I recorded were so far successful in attaining the object for which they were undertaken as to be adequate to the detection of the planet, I thought that an account of them in some detail would not be an unacceptable contribution to the Royal Astronomical Society.

The particular circumstances that led to the undertaking of these observations were of so novel a kind, and so characteristic of the progress of astronomical science, that I cannot avoid some reference to them, although they will no doubt be laid before the Society in all the detail that their historic importance demands. It will be sufficient to say that, in September 1845, Mr. Adams, Fellow of St. John's College, Cambridge, placed in my hands a paper containing the results of computations he had made to account for irregularities in the motion of *Uranus*, on the hypothesis of disturbances

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caused by a more distant planet. These results embraced the mass, mean distance, mean longitude at a given epoch, longitude of perihelion, and eccentricity of the orbit, of the disturbing body, and, what was of chief importance to the practical astronomer, its probable geocentric longitude at the end of September. A similar communication was made in the next month to the Astronomer Royal. The time was then unfavourable for commencing operations in search of the supposed planet, on account of its angular distance from opposition. I will not, however, conceal that this was not, as far as regards myself, the only reason that no attempt was made that year. It was so novel a thing to undertake observations simply in reliance upon theoretical deductions,—while the labour was certain, success appeared to be so uncertain,—that it is not surprising a disposition should have been felt to postpone such observations to others based on less speculative grounds. In no other way, I think, is it to be accounted for, that for nearly four months after the publication, at the beginning of last June, of M. LE VERRIER'S first determination of the probable longitude of the planet, not a single step appears to have been taken in any continental observatory in search of it. I know not whether the close agreement of M. LE VERRIER'S determination of the longitude with that which Mr. ADAMS had previously obtained, induced the Astronomer Royal to suggest to me the employment of the Northumberland telescope of this observatory in a systematic attempt to discover the planet. I can say, however, that this concurrent evidence of the reality of the disturbing body from two independent investigations, weighed strongly with me in coming to the determination of undertaking the observations in the face of the great amount of labour they might be expected to entail. Mr. AIRY'S suggestion was made in a note, dated July 9, 1846. The observations were commenced on July 29, three weeks before the planet was in opposition. Having made these preliminary statements, I propose now to describe my plan of operations and methods of observing, and then to give an account of the observations themselves and their results.

Very shortly after the date of the above-mentioned note, I received from the Astronomer Royal a paper, entitled "Suggestions for the Examination of a portion of the Heavens in search of the external Planet which is presumed to exist and to produce Disturbances in the Motion of *Uranus*." In that paper it was recommended to examine a zodiacal zone, having its centre in the ecliptic, at 325° of longitude, the investigations of Mr. ADAMS and M.

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Le Verrier having made it probable that the place of the supposed planet was not far from that position. The proposed extent of the zone was 15° of longitude in each direction from the central point, and 5° of latitude north and south. This space was divided into intervals of declination 1° in breadth, and the extent in right ascension was marked out for each interval, so as to make it easy to ascertain by interpolation the extent in right ascension corresponding to any given declination. Mr. Airy further recommended using a magnifying power not lower than 120, and estimated the breadth of zone this power would well take in to be 15′. The transits were to be taken at a single vertical wire, and the north polar distances to be estimated by means of several horizontal wires separated by intervals of 3′, accuracy in north polar distance being of less importance than accuracy in right ascension. The whole of the tract indicated above was to be swept over three times at least, one sweeping of the whole being finished before the next was begun. The magnitudes of the stars always to be noted. The results of each sweeping to be catalogued and laid down in charts. According to this plan, it was calculated that there would be eighty zones with an average length of one hour, and that the three sweeps would occupy 300 hours of observing.

My plan of operations was formed in the main upon the above recommendations. I was not deterred from the undertaking by the extent of work laid down, as no less an extent appeared to me at that time necessary to insure a successful search. In some particulars I was induced by my experience in the use of the Northumberland telescope, and by the nature of the apparatus that was most within my reach, to deviate from Mr. Airy's recommendations. For instance, I used a magnifying power of 166, having found that this power, for some reason, probably depending on the breadth of the emergent pencils, was more comfortable for vision through the large refractor than an inferior power. This also was the lowest power I could apply to the micrometer eye-piece. The breadth of the zone that could be well taken in by it was not more than 9′. The transits were taken at the toothed border of the comb of the micrometer, which I ascertained to be perfectly straight, and which for each day's observations was always carefully adjusted. The declination readings were integral revolutions and parts of a revolution of the micrometer, taken from the comb, and reckoned upwards and downwards for greater facility in numbering, the direction being indicated by + and −. The parts of a revolution were estimated to a *fourth*, by means of the intervals

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between the teeth of the comb, and occasionally to a *tenth*, when the star was of considerable brightness. One micrometer revolution is equal to 17″. The error of a single declination reading could not in this way well exceed 4″.

The limit as to the magnitude of the stars was determined as follows: after illuminating the field of view sufficiently to shew the comb for taking the transits, every star was observed which was not too faint to be seen with that degree of illumination. This limit included stars of the 11th magnitude. By taking stars of that order of magnitude, I found that, although the breadth of each zone was not more than 9′, they came in such quick succession that in dark nights there was seldom any intermission in setting down the observations. It was often the case, when the stars came in groups, that some were necessarily allowed to pass without recording their places. It also not unfrequently happened, when even the stars were more scattered, that several, of a degree of brightness which it was desirable not to let pass, had nearly the same right ascension; and in such instances it was either not possible to take them all, or, if the attempt were made, in the hurry of observing there was great chance of making mistakes. To obviate these inconveniences, and to make the search more complete, I adopted a supplementary mode of observing, which was suggested by a particular arrangement in the apparatus of the Northumberland equatoreal, and which, as it differs in principle from the methods usually employed in mapping stars, I will describe more particularly.

In the former of the two methods of observing adverted to above, the telescope was perfectly stationary, moving neither in hour-angle nor declination. In the other, the telescope, with polar frame and hour-circle, was carried by clock-movement nearly at the rate of sidereal time, but was not moved in declination. I shall distinguish the two methods by saying "telescope fixed" and "telescope moving." When the telescope was fixed, I had one assistant to aid in recording the observations. He sat at a table with the memorandum-book and chronometer before him, and his part was to begin counting from the chronometer on a signal being given, and to write down the time of transit, declination reading, and magnitude of the star, as I gave them out, together with such occasional remarks as the observations seemed to require. The method of observing with the telescope moving was conducted by means of a tangent screw attached to the polar frame, and a

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handle extending to the observer's seat, which enabled him to move the polar frame and telescope *relatively to the hour-circle*, while the hour-circle, polar frame, and telescope, were carried by the clock-movement. It is clear that in this way the stars might be brought up at leisure to the toothed border of the comb at which the bisections were made, without the risk of any star passing which it was thought desirable to take. This method, however, required reading off the hour-circle, by which, in fact, differences of right ascension were measured; and to carry on the observations with convenience and rapidity, it was necessary to have the help of my two assistants, Mr. MORGAN and Mr. BREEN. Mr. MORGAN noted down, on a signal, first, the chronometer time of bisection (which was not required with much accuracy), then the declination reading and magnitude of the star, as I gave them out, and, lastly, the hour-circle reading given by Mr. BREEN. Instead of bisecting the divisions of the hour-circle, it was more convenient to bisect the divisions of a small graduated arc, which I had the means of clamping to the hour-circle, the intervals between its divisions being well ascertained. The chronometer times were required for correcting differences of right ascension measured by the hour-circle for the hour-circle's rate. It will appear that in each of these methods the observer's eye was not required to quit the eye-piece, and that in the second method the recording of the observations could go on without cessation, however the stars were grouped.

On making trial of these methods, I found that with the telescope moving I took more stars in the same portion of the heavens than with the telescope fixed, but that *fewer* stars were taken in the same time; so that the former method occupied a considerably longer time in sweeping over a given portion of the heavens than the latter, but swept more completely. Finding this to be the case, and taking into account also the interruptions caused by winding up the clock and adjusting the tangent-screw when it had gone to its limit, I determined to proceed as follows: first, to go over the tract proposed to be scrutinised, or a portion of it at a time, with telescope fixed, taking as many stars as could be conveniently taken without risk of mistakes from too much haste, and then to go over the same portion with telescope moving. In this way there would be no chance of error from irregularities or interruptions in the going of the clock, as the first sweep would always furnish a sufficient number of points of reference for determining the clock's rate at any time for the second sweep. Also, as the second sweep might be expected to include *all* the stars contained in the first, the probability was that the object for

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which the observations were undertaken would be attained by the second sweep, without the necessity of a third. If, however, it turned out otherwise, I intended to go over the tract a *third* time; and, if this scrutiny proved unsuccessful, I should only have had the satisfaction of mapping a certain portion of the heavens so as to include stars to the 11th magnitude, and all brighter, in a more perfect manner than in any previous undertaking of a similar kind.

To complete the detail of the methods of observing, a few more particulars require to be mentioned. On nights of strong moonlight, in which the fainter stars could not be seen, the method of observing with the telescope fixed was alone adopted. When it happened (as it often did happen) that a cloud came over and obscured the field of view, I immediately left my seat, if the telescope at the time were fixed, and set the clock going, directing at the same time my assistant to draw a line separating the observations before such an occurrence from those that followed. On resuming the observations after the cloud removed, the star last taken before the interruption was the first of the new series. If the same thing happened when the telescope was moving, it was only necessary to remain idle till the cloud had passed; the observation of the star taken just before the cloud came over was, however, generally repeated. For the purpose of determining precisely the positions of the zones, stars of reference were taken in each series. To explain how this was done, it is necessary to state that the Northumberland equatoreal has no declination circle, the setting of the telescope in north polar distance being effected by graduated *rods*. The rod remaining in position, the telescope, by an arrangement proper for the purpose, is movable in north polar distance through 80′, and arcs to that extent may be measured by means of a graduated sector arc and microscope micrometer. When, therefore, on looking into the finder, a star was seen within reach of the sector, and bright enough to be likely to be in standard catalogues, by turning the sector milled head it was brought into the field of view of the large telescope; it was then accurately bisected by a fixed micrometer wire, a transit of it was taken, and the sector microscope micrometer was read off. The telescope was afterwards accurately restored to its former position by means of the sector-arc and its microscope micrometer. The readings of the hour-circle and declination rod being noted, and the error of the chronometer ascertained by comparison with the transit clock, it was easy to identify the reference star. On one occasion the observations were entirely conducted in the manner just stated, the

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telescope being moved in declination upwards and downwards through 80′, while the instrument was motionless about the polar axis. In this instance brighter stars only were selected, being intended as points of reference for the observations in narrow zones.

It will be proper to explain here why no use was made of hour xxi. of the Berlin star-maps. The only reason I have to give is, that I was entirely ignorant of its publication. In a note, dated July 21, Mr. AIRY remarked that but a small portion of the Berlin maps applied to this inquiry. I found accordingly, in the library of the University of Cambridge, hour xxii., which extends over a small part of the space intended to be scrutinised; but I did not find hour xxi., and consequently concluded that it was not published. If I had had this map, a first sweep would have been unnecessary; my course would have been to compare my observations with the map as fast as I recorded them.

Having thus given an account of the plan of operations, I proceed to the observations themselves. As already stated, I commenced observing July 29. The first observations were for the most part made for trial of different methods of observing; but, not to throw away any chance of detecting the planet, I thought it advisable at the very outset to direct the telescope to the part of the heavens which theory had indicated as the most probable position. In doing this, I was guided by a paper drawn up for me by Mr. ADAMS, which I found to be of great assistance. This paper contained the right ascensions and declinations of the planet (calculated on the supposition of its moving in the ecliptic, but in other respects entirely from theoretical data) for every twentieth day from July 20 to October 8, and for every fifth degree of heliocentric longitude from 315° to 335° inclusive. I selected for guidance the positions corresponding to 325° of longitude, which, I think, are well deserving of being recorded here.

For 325° of Heliocentric Longitude.

Date.	Planet's Right Ascension.	Planet's Declination.
	h m	° ′
July 20	21 51·3	−13 0
Aug. 9	21 49·5	−13 9
29	21 47·9	−13 18
Sep. 18	21 46·5	−13 26
Oct. 8	21 45·1	−13 33

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By the observations of July 29 I found it would not be possible to include, by the method of transits with telescope fixed, all the stars which it then appeared to me desirable to take, and accordingly, on July 30, I made trial of the second method, in which the telescope and polar frame were carried by clock-movement. The next observations were made on August 4, on which day the telescope was moved in declination by the milled head of the sector, in the manner already described, the reading of the declination rod remaining the same as on July 29 and 30. The particular purpose of these observations being to obtain reference points for fixing the positions of the zones of 9′ breadth, they were made with more than usual accuracy, the stars being all carefully bisected by the micrometer wire, and the transits taken at the same part of the field. The only source of inaccuracy was the mode of reading off the sector microscope micrometer. The integral number of micrometer revolutions were taken as usual from the comb, but, to save time, the parts of a revolution were estimated to a *fourth* by inspection from the intervals between the teeth of the comb. As the value of one revolution is 10″, I do not think that an error of more than 3″ could be committed in this way in a single reading off.

Moonlight and the weather preventing, the next observations were not made till August 12. On this day the telescope was fixed, and the stars were taken in a zone 9′ broad, having the same position as that of July 30, but of greater extent in right ascension. Very shortly after (probably the next day, but, as I have no memorandum of the time, I cannot say with certainty), I made a comparison in part of these observations with those of July 30, for the purpose of testing the efficiency of the method of observing with telescope moving. To the extent that I made the comparison, I found that *every* star taken on August 12 with telescope fixed was included in the stars taken on July 30 with telescope moving. This result satisfied me as to the adequacy of this method for the object I had in view. Having by these preliminary observations obtained a pretty good idea of the rate at which the work was likely to go on, I observed subsequently earlier in right ascension, for the sake of being able to go over in the present year as large a portion as possible of the space to be explored. The observations were continued during two months at all available opportunities, and were made principally with the telescope fixed; but the ground was partly, also, gone over again with the telescope moving. On September 29 I read, for the first time, the com-

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munication made by M. Le Verrier to the Academy of Sciences at Paris, on August 31, in which he expressly recommends the endeavour to detect the planet by the appearance of a disk. Mr. Adams had found by his investigations the mass to be about three times that of *Uranus*, and inferred from this result that its brightness would not be less than that of a star of the 9th magnitude. This inference he communicated to me in conversation to be a guide to me in my search. I continued, however, as I had begun, to include stars of the 11th magnitude.

The general accordance of M. Le Verrier's results respecting the mass and orbit of the unknown planet with those of Mr. Adams, previously known to me, inspired renewed confidence in the theoretical deductions, and induced me to alter my plan of operations. On the evening of September 29, I swept over a considerable breadth in declination, within the limits of longitude marked out by M. Le Verrier, resolving, if possible, to include the planet. The night was a good one; I observed without intermission three hours and a half, and recorded the positions of nearly 300 stars, paying more particular attention to the physical appearance of the brighter stars. *One* only attracted my attention, against which I directed my assistant to note, "It seems to have a disk." No observations were taken the next night, the moon being in the way; and on October 1, I received information of the discovery made by Dr. Galle on September 23. Thus my labours were brought to a close. The total number of positions I have recorded is above 3000; they are contained in but a small portion of the space intended to be explored, and refer for the most part to stars of very small magnitude. I had made preparations for mapping the places of the stars, but at present I think it hardly worth while to resume this labour. It remains for me now to mention some results deducible from the observations.

On receiving the account of Dr. Galle's discovery, I soon perceived that the star which drew my attention on September 29 was the planet. Its place, deduced from one known star taken in the same series, viz. B. A. C. 7599, was as follows:—

	Greenwich Mean Time.	Right Ascension.	North Polar Distance.
Sept. 29	$10^h\ 10^m$	$21^h\ 52^m\ 48^s.9$	$103^\circ\ 26'\ 30''$

This place is not given as having any pretension to accuracy, but as a verification, possessing some historic interest, of the remarkable prediction by

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M. LE VERRIER, that the planet was discoverable in good telescopes by its physical appearance.

On examining my early observations, I had the great vexation of finding that, if I had completed the comparison of the observations of July 30 and August 12, I should have discovered the planet, and spared myself all further labour. In the first examination, I found that every star, to No. 39 of the series taken on August 12 with telescope fixed, was in the series taken on July 30 with telescope moving. If I had gone on to No. 49, I should have found that *a star of the 8th magnitude was wanting in the latter series.* According to the principle of the search, this could be nothing less than a planet: it had wandered into the zone in the interval between July 30 and August 12. The only reason I can now give for not carrying the comparison further is, that the observations were interrupted at No. 39 by a cloud, the clock was set going, and a line of separation drawn in the memorandum-book. I proceeded to this line and no further.

After deducing the position of August 12, I was led to see that I recorded another on August 4; on which day, it will be remembered, the stars taken were intended to be reference points for other observations. To be quite sure of this second position, I have since directed the telescope to that point of the heavens, and found that no star is now to be seen there.

From the foregoing narrative it will appear, that it only required proceeding a little way in mapping the recorded positions of the stars to detect the planet. I delayed doing this, partly from being occupied with comet reductions, and partly from the fixed impression I had, that a long search was required to insure success. I confess that, in the whole of the undertaking, I had too little confidence in the indications of theory, though perhaps not less than most astronomers might have felt under the same circumstances.

As the places of the planet on Aug. 4 and Aug. 12 are the earliest on record, as far as is hitherto known, I have thought it worth while to give them with as much accuracy as the nature of the observations admits of. They have a value at present which they will lose when accurate observations have been continued a longer period. I propose, therefore, to give the places resulting from comparisons with all the known stars taken in the same series, and to regard the mean of the results as the best determination that the case affords.

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Place of the Planet on Aug. 4.

Star of Camparison and Authority for its Place.		R.A. of Planet.	N.P.D. of Planet.
		h m s	° ′ ″
50 Capricorni	Bessel Z., 127	21 58 15·21	102 57 21·7 *
	British Association Catalogue..	14·13	18·4 *
British Association Catalogue, No. 7599		14·89	32·0
38 Aquarii, B.A.C. 7722		14·86	41·9*
Bessel Z., 127 and 129	$21^h 59^m 10^s$	14·48	33·6
—— 127 and 129	22 5 6	14·80	34·9
—— 127	21 45 34	14·69	28·4
—— 127	21 34 54	14·18	35·1
—— 127	21 32 30	14·94	30·2
—— 127	21 48 50	21 58 14·77	102 57 33·6

Place of the Planet on Aug. 12.

Star of Comparison and Authority for its Place.		R.A. of Planet.	N.P.D. of Planet.
	h m s	h m s	° ′ ″
Bessel Z., 127	22 0 51	21 57 26·14	103 1 55·2
—— 127 and 129	5 6	25·98	64·0
—— 127 and 129	8 15	26·27	59·3
—— 127 and 129	10 53	26·05	61·5
—— 127 and 129	11 18	26·10	61·9
—— 127	18 20	25·99	62·7
—— 127	19 26	26·32	60·9
—— 127	24 45	26·35	54·4
—— 127 and 129	32 7	26·21	57·8
—— 129	27 31	25·99	65·2
—— 127	22 36 51	25·84	62·7
75 Aquarii, B.A.C. 7976	....	21 57 26·34	103 1 57·1

Not knowing whether Bessel's place of 50 *Capricorni* or that of the British Association Catalogue is to be preferred, I have adopted the mean of the two, which agrees very well with Piazzi's place. Taking the mean of all the determinations on the respective days, I find the following positions of the planet:—

	Greenwich Mean Time.	R.A. of Planet.	N.P.D. of Planet.
	h m s	h m s	° ′ ″
Aug. 4	13 36 25	21 58 14·70	102 57 32·2
12	13 3 26	21 57 26·13	103 2 0·2

The errors of right ascension are probably not greater than those incidental to determinations by single transits. From estimations already made, the error of north polar distance in the mean of the results by all the stars of

* There can be little doubt that in these there is an error of one micrometer revolution, and that the first should be increased and the other diminished by 10″.

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comparison, may amount to 3″ on Aug. 4, and to 4″ on Aug. 12. It should be mentioned that, on the latter day, the parts of the micrometer revolution in the observation of the planet were estimated to a *tenth*, and not, as in general, to a *fourth*, implying more than usual care in taking the observation. To give an idea of the weight to be attached to the place of Aug. 12, I calculated the right ascension and north polar distance of 75 *Aquarii* by the same process as that by which the planet's place was obtained, and compared the results with the right ascension and north polar distance of the British Association Catalogue. The difference of right ascension was 0ˢ·23, and that of north polar distance 3″·43.

The foregoing places appearing to be worthy of confidence, Mr. ADAMS employed them, in conjunction with recent observations extending to Oct. 13, to approximate to some elements of the planet's orbit.

The following are the only results which the data allowed of obtaining with any degree of certainty:—

Distance of the Planet from the Sun	30·05
Heliocentric Longitude, August 4	326° 39′
Longitude of the Descending Node	309 43
Inclination of the Orbit	1 45

The immediate use we made of these results was to endeavour to find incidental observations of the planet in existing catalogues of stars. The search has hitherto been unsuccessful. The probable position of the planet at the date of the *Histoire Céleste* is now too near the sun to allow of ascertaining, by actual observation, whether any place is recorded in that catalogue.

In closing this narrative, I beg to direct attention more especially to the method of observing, which I have designated by the terms "telescope moving." I have given a particular description of it from a conviction of the utility, and even necessity, of this or some equivalent method, if the wants of astronomy should require the registering of the approximate places of *all* stars to a certain magnitude. In the course of making the observations which are the subject of this communication, the fact that the stars are more generally disposed in *groups*, than scattered equally over the celestial spaces, very frequently came under notice, and strongly impressed me with the importance of employing some method like that I have described, to be supplementary to the ordinary method of transits.

J. CHALLIS.

Cambridge Observatory, Nov. 12, 1846.

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XVI. *An Explanation of the Observed Irregularities in the Motion of Uranus, on the Hypothesis of Disturbances caused by a more Distant Planet; with a Determination of the Mass, Orbit, and Position of the Disturbing Body. By J. C. Adams, Esq. M.A. F.R.A.S. Fellow of St. John's College, Cambridge, and Fellow of the Cambridge Philosophical Society.*

Read November 13, 1846.

1. The irregularities in the motions of *Uranus* have for a long time engaged the attention of astronomers. When the path of the planet became approximately known, it was found that, previously to its discovery by Sir W. Herschel in 1781, it had several times been observed as a fixed star by Flamsteed, Bradley, Mayer, and Lemonnier. Although these observations are doubtless very far inferior in accuracy to the modern ones, they must be considered valuable, in consequence of the great extension which they give to the observed arc of the planet's orbit. Bouvard, however, to whom we owe the tables of *Uranus* at present in use, found that it was impossible to satisfy these observations without attributing much larger errors to the modern observations than they admit of, and consequently founded his Tables exclusively on the latter. But, in a very few years, sensible errors began again to shew themselves, and, though the tables were formed so recently as 1821, their error at the present time exceeds two minutes of space, and is still rapidly increasing. There appeared, therefore, no longer any sufficient reason for rejecting the ancient observations, especially since, with the exception of Flamsteed's first observation, which is more than twenty years anterior to any of the others, they are mutually confirmatory of each other.

2. Now that the discovery of another planet has confirmed in the most brilliant manner the conclusions of analysis, and enabled us with certainty to refer these irregularities to their true cause, it is unnecessary for me to enter at length upon the reasons which led me to reject the various other

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comparison, may amount to 3″ on Aug. 4, and to 4″ on Aug. 12. It should be mentioned that, on the latter day, the parts of the micrometer revolution in the observation of the planet were estimated to a *tenth*, and not, as in general, to a *fourth*, implying more than usual care in taking the observation. To give an idea of the weight to be attached to the place of Aug. 12, I calculated the right ascension and north polar distance of 75 *Aquarii* by the same process as that by which the planet's place was obtained, and compared the results with the right ascension and north polar distance of the British Association Catalogue. The difference of right ascension was 0ˢ·23, and that of north polar distance 3″·43.

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2. Now that the discovery of another planet has confirmed in the most brilliant manner the conclusions of analysis, and enabled us with certainty to refer these irregularities to their true cause, it is unnecessary for me to enter at length upon the reasons which led me to reject the various other

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hypotheses which had been formed to account for them. It is sufficient to say, that they all appeared to be very improbable in themselves, and incapable of being tested by any exact calculation. Some had even supposed that, at the great distance of *Uranus* from the sun, the law of attraction becomes different from that of the inverse square of the distance. But the law of gravitation was too firmly established for this to be admitted till every other hypothesis had failed, and I felt convinced that in this, as in every previous instance of the kind, the discrepancies which had for a time thrown doubts on the truth of the law, would eventually afford the most striking confirmation of it.

3. My attention was first directed to this subject several years since, by reading Mr. Airy's valuable Report on the recent progress of Astronomy. I find among my papers the following memorandum, dated July 3, 1841: "Formed a design, in the beginning of this week, of investigating, as soon as possible after taking my degree, the irregularities in the motion of *Uranus*, which are yet unaccounted for, in order to find whether they may be attributed to the action of an undiscovered planet beyond it, and, if possible, thence to determine approximately the elements of its orbit, &c., which would probably lead to its discovery." Accordingly, in 1843, I attempted a first solution of the problem, assuming the orbit to be a circle, with a radius equal to twice the mean distance of *Uranus* from the sun. Some assumption as to the mean distance was clearly necessary in the first instance, and Bode's law appeared to render it probable that the above would not be far from the truth. This investigation was founded exclusively on the modern observations, and the errors of the tables were taken from those given in the equations of condition of Bouvard's tables as far as the year 1821, and subsequently from the observations given in the *Astronomische Nachrichten*, and from the Cambridge and Greenwich Observations. The result shewed that a good general agreement between theory and observation might be obtained; but the larger differences occurring in years where the observations used were deficient in number, and the Greenwich Planetary Observations being then in process of reduction, I applied to Mr. Airy, through the kind intervention of Professor Challis, for the observations of some years in which the agreement appeared least satisfactory. The Astronomer Royal, in the kindest possible manner, sent me in February 1844 the results of all the Greenwich Observations of *Uranus*.

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4. Meanwhile the Royal Academy of Sciences of Göttingen had proposed the theory of *Uranus* as the subject of their mathematical prize, and although the little time which I could spare from important duties in my college prevented me from attempting the complete examination of the theory which a competition for the prize would have required, yet this fact, together with the possession of such a valuable series of observations, induced me to undertake a new solution of the problem. I now took into account the most important terms depending on the first power of the eccentricity of the disturbing planet, retaining the same assumption as before with respect to the mean distance. For the modern observations, the errors of the tables were taken exclusively from the Greenwich Observations as far as the year 1830, with the exception of an observation by Bessel in 1823; and subsequently from the Cambridge and Greenwich Observations, and those given in various numbers of the *Astronomische Nachrichten*. The errors of the tables for the ancient observations were taken from those given in the equations of condition of Bouvard's tables. After obtaining several solutions differing little from each other, by gradually taking into account more and more terms of the series expressing the perturbations, I communicated to Professor Challis, in September 1845, the final values which I had obtained for the mass, heliocentric longitude, and elements of the orbit of the assumed planet. The same results, slightly corrected, I communicated in the following month to the Astronomer Royal. The eccentricity coming out much larger than was probable, and later observations shewing that the theory founded on the first hypothesis as to the mean distance was still sensibly in error, I afterwards repeated my investigation, supposing the mean distance to be about $\frac{1}{30}$th part less than before. The result, which I communicated to Mr. Airy in the beginning of September of the present year, appeared more satisfactory than my former one, the eccentricity being smaller, and the errors of theory, compared with late observations, being less, and led me to infer that the distance should be still further diminished.

5. In November 1845, M. Le Verrier presented to the Royal Academy of Sciences, at Paris, a very complete and elaborate investigation of the theory of *Uranus*, as disturbed by the action of *Jupiter* and *Saturn*, in which he pointed out several small inequalities which had previously been neglected; and in June, of the present year, he followed up this investigation by

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a memoir, in which he attributed the residual disturbances to the action of another planet at a distance from the sun equal to twice that of *Uranus*, and found a longitude for the new planet agreeing very nearly with the result which I had obtained on the same hypothesis. On the 31st of August, he presented to the Academy a more complete investigation, in which he determined the mass and the elements of the orbit of the new planet, and also obtained limiting values of the mean distance and heliocentric longitude. I mention these dates merely to shew that my results were arrived at independently, and previously to the publication, of those of M. Le Verrier, and not with the intention of interfering with his just claims to the honours of the discovery; for there is no doubt that his researches were first published to the world, and led to the actual discovery of the planet by Dr. Galle, so that the facts stated above cannot detract, in the slightest degree, from the credit due to M. Le Verrier.

6. In order not to have an inconvenient number of equations of condition, I divided the modern observations into groups, each including a period of three years, and as Mr. Airy had shewn that the error of the tabular radius vector was sometimes considerable, I either selected those observations which were made near opposition, or combined the others in such a manner that the results should be nearly free from the effects of this error. From the observations of each group, the error of the tables in heliocentric longitude was found, corresponding to the time of mean opposition in the middle year of the group. Thus were formed 21 normal errors of the tables, corresponding to as many equidistant periods between 1780 and 1840. The error for 1780 was found by interpolating between the errors of 1781, 1782, and 1783, and those given by the ancient observations of 1769 and 1771; and though not entitled to the same weight as the others, cannot, I think, be liable to much uncertainty. In my last calculations I might have used more recent observations, but in order to obtain the effect due to the change of mean distance, it was necessary that the investigation should be founded on the same elements as before, and the later observations might be used as a test of the theory.

7. In order to satisfy myself that there was no important error in Bouvard's tables, I recomputed all the principal inequalities produced by the action of *Jupiter* and *Saturn*, and found no difference of any consequence,

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except in the equation depending on the mean longitude of *Saturn* minus twice that of *Uranus*, the error of which had been already pointed out by Bessel. The principal equation depending on the action of *Jupiter* also required correction, in consequence of the increased value which has been lately obtained for the mass of that planet. The corrections to be applied to Bouvard's tables on these accounts are the following:—

$$+1''.918 \sin\{\varphi_1 - 2\varphi_2 - 13^\circ\ 1'.5\}$$
$$+1.085 \sin\{\varphi - \varphi_2\}$$

φ, φ_1, φ_2 being the mean longitudes of *Jupiter*, *Saturn*, and *Uranus*, respectively. In the reduction of the Greenwich Observations, the latter correction was already taken into account. M. Hansen having also found some new inequalities in the motion of *Uranus*, depending on the square of the disturbing force, I re-computed the values of these, following the same method as that given by M. Delaunay in the *Conn. des Temps* for 1845, and my results agreed very closely with his, the terms to be added to the longitude being

$$+32''.00 \sin\{3\varphi_2 - 6\varphi_1 + 2\varphi + 22^\circ\ 18'.8\}$$
$$-\ 8.35 \sin\{2\varphi_2 - 6\varphi_1 + 2\varphi + 39\ 10.5\}$$
$$-\ 1.49 \sin\{4\varphi_2 - 6\varphi_1 + 2\varphi + 34\ 48.4\}$$

With respect to the inequalities of higher orders neglected by Bouvard, I considered that the most important of them would be, either those of long period, or those whose period was nearly equal to that of *Uranus*. During three-fourths of a revolution of the planet, the effects of the former class would be nearly confounded with those arising from a change in the epoch and mean motion, and those of the latter class with the effects produced by a constant change in the eccentricity and longitude of the perihelion. The position of the planet to be determined would, therefore, be little affected by these terms, and the others would probably be much smaller than those which would necessarily be neglected in a first approximation to the perturbations produced by the new planet.

8. Taking into account the several corrections above-mentioned, the residual differences between the theoretical and observed heliocentric longitudes were the following:—

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Ancient Observations.

Year.	Observation—Theory.
1690	+61″·2
1712	+92·7
1715	+73·8
1750	−47·6
1753	−39·5
1756	−45·7
1764	−34·9
1769	−19·3
1771	− 2·3

Modern Observations.

Year.	Observation—Theory.
1780	+ 3″·46
1783	+ 8·45
1786	+12·36
1789	+19·02
1792	+18·70
1795	+21·38
1798	+20·95
1801	+22·21
1804	+24·16
1807	+22·07
1810	+23·16
1813	+22″·00
1816	+22·88
1819	+20·69
1822	+20·97
1825	+18·16
1828	+10·82
1831	− 3·98
1834	−20·80
1837	−42·66
1840	−66·64

9. It is easily seen, that the series expressing the correction of the *mean* longitude in terms of the corrections applied to the elements of the orbit, is more convergent than that which gives the correction of the *true* longitude, and the same thing is true for the perturbations of the mean longitude, as compared with those of the true. The corrections found above were accordingly converted into corrections of mean longitude by multiplying each of them by the factor $\frac{r^2}{ab}$, r being the radius vector, and a and b the semi-axes of the orbit. Hence these latter corrections were found to be the following:—

Ancient Observations.

Year.	Observation—Theory.
1690	+62″·6
1712	+84·5
1715	+67·2
1750	−51·8
1753	−43·2
1756	−50·1
1764	−37·8
1769	−20·5
1771	− 2·4

Modern Observations.

Year.	Observation—Theory.
1780	+ 3″·42
1783	+ 8·19
1786	+11·74
1789	+17·75
1792	+17·22
1795	+19·52
1798	+19·06
1801	+20·24
1804	+22·19
1807	+20·52
1810	+21·89
1813	+21″·19
1816	+22·50
1819	+20·78
1822	+21·50
1825	+18·97
1828	+11·50
1831	− 4·29
1834	−22·63
1837	−46·70
1840	−73·09

These numbers form the basis of the subsequent investigations.

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10. Let $\delta\epsilon$, δa, δe, and $\delta\varpi$ denote the corrections to be applied to the tabular elements of *Uranus*, then the correction of the mean longitude at any time t is

$$= \delta\epsilon + 2e^2\delta\varpi + t\delta n - \{2\cos(nt+\epsilon-\varpi) + \frac{e}{2}\cos 2(nt+\epsilon-\varpi)\}\, e\delta\varpi$$
$$+ \{2\sin(nt+\epsilon-\varpi) + \frac{e}{2}\sin 2(nt+\epsilon-\varpi)\}\,\delta e$$

If we include the small term $2e^2\delta\varpi$ in the quantity $\delta\epsilon$, this correction may be put under the following form:—

$$\delta\epsilon + t\delta n + \cos nt\,\delta x_1 + \sin nt\,\delta y_1 + \cos 2nt\,\delta x_2 + \sin 2nt\,\delta y_2$$

in which expression

$$\delta x_2 = \frac{1}{4}e\{\cos(\epsilon-\varpi)\,\delta x_1 + \sin(\epsilon-\varpi)\,\delta y_1\}$$
$$\delta y_2 = -\frac{1}{4}e\{\sin(\epsilon-\varpi)\,\delta x_1 + \cos(\epsilon-\varpi)\,\delta y_1\}$$

11. Also, adopting the notation of Pontécoulant's *Théorie Analytique*, the perturbations of mean longitude

$$= \frac{m'}{2}\Sigma F_i \sin i(nt-n't+\epsilon-\epsilon')$$
$$+ m'e\,\Sigma G_i \sin\{i(nt-n't+\epsilon-\epsilon') - (nt+\epsilon-\varpi)\}$$
$$+ m'e'\,\Sigma H_i \sin\{i(nt-n't+\epsilon-\epsilon') - (nt+\epsilon-\varpi')\}$$

Where the accented letters belong to the disturbing planet, i takes all integral values, positive and negative, except zero, and if we put $i(n-n') = z$, the values of F_i G_i and H_i are the following:—

$$F_i = \left\{\frac{3in^4}{z^2(z^2-n^2)} + \frac{in^2}{z^2-n^2}\right\} aA_i + \frac{2n^3}{z(z^2-n^2)}a^2\frac{dA_i}{da}$$

$$G_i = \left\{-\frac{3i(i-1)n^4}{(z-n)^2 z(z-2n)} - \frac{i(i+1)n^2}{z(z-2n)} + \frac{in^2}{z^2-n^2} + \frac{3in^3}{z(z-n)(z-2n)}\right\} aA_i$$
$$+ \left\{-\frac{3}{2}\frac{(i-1)n^4}{(z-n)^2 z(z-2n)} - \frac{1}{2}\frac{(i-1)n^2}{z(z-2n)} - \frac{1}{2}\frac{n^2}{z^2-n^2} - \frac{2in^3}{z(z-n)(z-2n)}\right\} a^2\frac{dA_i}{da}$$
$$- \frac{n^3}{z(z-n)(z-2n)}a^3\frac{d^2A_i}{da^2}.$$

$$H_i = \left\{\frac{3}{2}\frac{(i-1)(2i-1)n^4}{(z-n)^2 z(z-2n)} + \frac{1}{2}\frac{(i-1)(2i-1)n^2}{z(z-2n)}\right\} aA_{i-1}$$
$$+ \left\{\frac{3}{2}\frac{(i-1)n^4}{(z-n)^2 z(z-2n)} + \frac{1}{2}\frac{(i-1)n^2}{z(z-2n)} + \frac{2in^3}{z(z-n)(z-2n)}\right\} a^2\frac{dA_{i-1}}{da}$$
$$+ \frac{n^3}{z(z-n)(z-2n)}a^3\frac{d^2A_{i-1}}{da^2}.$$

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12. Now, if we assume $\frac{a}{a'}$ or $\alpha = \sin 30^\circ = 0{\cdot}5$, the values of the fundamental quantities b, $\alpha \frac{db}{d\alpha}$, $a^2 \frac{d^2 b}{da^2}$, will be

$\log b_0 = 0{\cdot}33170$	$\log \alpha \frac{db_0}{d\alpha} = 9{\cdot}53765$	$\log \alpha^2 \frac{d^2 b_0}{d\alpha^2} = 9{\cdot}77848$
$\log b_1 = 9{\cdot}74497$	$\log \alpha \frac{db_1}{d\alpha} = 9{\cdot}83868$	$\log \alpha^2 \frac{d^2 b_1}{d\alpha^2} = 9{\cdot}70857$
$\log b_2 = 9{\cdot}32425$	$\log \alpha \frac{db_2}{d\alpha} = 9{\cdot}68012$	$\log \alpha^2 \frac{d^2 b_2}{d\alpha^2} = 9{\cdot}87776$
$\log b_3 = 8{\cdot}94670$	$\log \alpha \frac{db_3}{d\alpha} = 9{\cdot}46315$	$\log \alpha^2 \frac{d^2 b_3}{d\alpha^2} = 9{\cdot}86253$

Hence the principal inequalities of mean longitude, produced by the action of a planet whose mass is $\frac{m'}{5000}$, that of the sun being unity, and the eccentricity of whose orbit is $\frac{e'}{20}$ will be the following:—

$$
\begin{aligned}
&-36''{\cdot}99\, m' \sin \{nt - n't + \epsilon - \epsilon'\} \\
&+58{\cdot}97\, m' \sin 2\{nt - n't + \epsilon - \epsilon'\} \\
&+\ 5{\cdot}80\, m' \sin 3\{nt - n't + \epsilon - \epsilon'\} \\
&+\ 2{\cdot}06\, m' \sin \{n't + \epsilon' - \varpi\} \\
&-\ 4{\cdot}30\, m'e' \sin \{n't + \epsilon' - \varpi'\} \\
&+31{\cdot}25\, m' \sin \{nt - 2n't + \epsilon - 2\epsilon' + \varpi\} \\
&-12{\cdot}14\, m'e' \sin \{nt - 2n't + \epsilon - 2\epsilon' + \varpi'\} \\
&+48{\cdot}55\, m' \sin \{2nt - 3n't + 2\epsilon - 3\epsilon' + \varpi\} \\
&-93{\cdot}01\, m'e' \sin \{2nt - 3n't + 2\epsilon - 3\epsilon' + \varpi'\}
\end{aligned}
$$

To these may be added the following, which are of two dimensions in terms of the eccentricities:—

$$
\begin{aligned}
&+0''{\cdot}57\, m' \sin 3\{nt - n't + \epsilon - \epsilon'\} \\
&-1{\cdot}08\, m'e' \sin \{3(nt - n't + \epsilon - \epsilon') - \varpi + \varpi'\}
\end{aligned}
$$

These expressions may be put under the following form:—

$$
\begin{aligned}
&h_1 \cos (n - n')t + h_2 \cos 2(n - n')t + h_3 \cos 3(n - n')t \\
&+k_1 \sin (n - n')t + k_2 \sin 2(n - n')t + k_3 \sin 3(n - n')t \\
&+p_1 \cos n't + p_2 \cos (n - 2n')t + p_3 \cos (2n - 3n')t \\
&+q_1 \sin n't + q_2 \sin (n - 2n')t + q_3 \sin (2n - 3n')t
\end{aligned}
$$

13. Let the time of the mean opposition in 1810 be taken as the epoch from which t is reckoned; this date, expressed in decimal parts of a year,

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will be 1810·328. Also, let 3 synodic periods of *Uranus*, = 3·0362 years, be taken for the unit of time; then the change of the mean anomaly in an unit of time will be 13° 0′·5; also $n = 13^\circ\,0'\cdot6$, $n' = 4^\circ\,36'\cdot0$ ∴ $n-n' = 8^\circ\,24'\cdot6$, $n-2n' = 3^\circ\,48'\cdot6$, $2n-3n' = 12^\circ\,13'\cdot2$. Hence the equations of condition given by the modern observations will be of the form

$$\begin{aligned} c'' = {} & \delta\varepsilon + \delta x_1 \cos\{13^\circ\ 0'\cdot5\}\,t + \delta x_2 \cos\{26^\circ\ 1'\cdot0\}\,t \\ & + t\delta n + \delta y_1 \sin\{13\ \ 0\cdot5\}\,t + \delta y_2 \sin\{26\ \ 1\cdot0\}\,t \\ & + h_1 \cos\{8^\circ\ 24'\cdot6\}\,t + h_2 \cos\{16^\circ\ 49'\cdot2\}\,t + h_3 \cos\{25^\circ\ 13'\cdot8\}\,t \\ & + k_1 \sin\{8\ \ 24\cdot6\}\,t + k_2 \sin\{16\ \ 49\cdot2\}\,t + k_3 \sin\{25\ \ 13\cdot8\}\,t \\ & + p_1 \cos\{4^\circ\ 36'\cdot0\}\,t + p_2 \cos\{3^\circ\ 48'\cdot6\}\,t + p_3 \cos\{12^\circ\ 13'\cdot2\}\,t \\ & + q_1 \sin\{4\ \ 36\cdot0\}\,t + q_2 \sin\{3\ \ 48\cdot6\}\,t + q_3 \sin\{12\ \ 13\cdot2\}\,t \end{aligned}$$

in which t assumes all integral values from − 10 to + 10 in succession, and the several values of c'' are contained in the table given in Article 9.

14. The final equations for the corrections of the elliptic elements will be found by multiplying each equation successively by the coefficients of $\delta\varepsilon$, δn, δx_1, and δy_1, which occur in it, and adding the several results.

Let the equations be treated in a similar manner with reference to the quantities h_1, k_1, h_2, k_2, h_3, k_3, p_2, q_2, p_3, q_3.

It will be seen that, in consequence of the arrangement which has been given to the equations of condition, the equations thus formed naturally separate themselves into two groups, one of which involves only $\delta\varepsilon$, δx_1, δx_2, with the quantities h and p, while the other involves δn, δy_1, δy_2, with the quantities k and q.

Also the coefficients in these equations are easily calculated by the following formulæ, putting $t = 10$ in their right-hand members:—

$$\Sigma\, 2\cos mt = \frac{\sin m\,(t+\frac{1}{2})}{\sin \frac{1}{2} m}$$

$$\Sigma\, 2\,t \sin mt = \frac{(t+1)\sin mt - t\sin m\,(t+1)}{2\sin^2 \frac{1}{2} m}$$

$$\Sigma\, 2\cos mt \cos nt = \frac{1}{2}\left\{\frac{\sin (m-n)\,(t+\frac{1}{2})}{\sin \frac{1}{2}(m-n)} + \frac{\sin (m+n)\,(t+\frac{1}{2})}{\sin \frac{1}{2}(m+n)}\right\}$$

$$\Sigma\, 2\sin mt \sin nt = \frac{1}{2}\left\{\frac{\sin (m-n)\,(t+\frac{1}{2})}{\sin \frac{1}{2}(m-n)} - \frac{\sin (m+n)\,(t+\frac{1}{2})}{\sin \frac{1}{2}(m+n)}\right\}$$

$$\Sigma\, 2\cos^2 mt = t + \frac{1}{2} + \frac{1}{2}\frac{\sin m\,(2t+1)}{\sin m}$$

$$\Sigma\, 2\sin^2 mt = t + \frac{1}{2} - \frac{1}{2}\frac{\sin m\,(2t+1)}{\sin m}$$

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15. By performing the calculations, the equations of the first group are found to be the following :—

$$
\begin{aligned}
(\varepsilon)\quad 151''.48 = {} & 21.0000\,\delta\varepsilon + 6.0670\,\delta x_1 - 4.4358\,\delta x_2 \\
& + 13.6320\,h_1 + 0.4043\,h_2 - 4.5608\,h_3 \\
& + 18.6046\,p_1 + 19.3384\,p_2 + 7.3721\,p_3 \\
(x)\quad 246.48 = {} & 6.0670\,\delta\varepsilon + 8.2821\,\delta x_1 + 4.1762\,\delta x_2 \\
& + 7.4041\,h_1 + 8.2523\,h_2 + 4.6963\,h_3 \\
& + 6.5389\,p_1 + 6.3978\,p_2 + 8.1831\,p_3 \\
(h_1)\quad 209.74 = {} & 13.6320\,\delta\varepsilon + 7.4041\,\delta x_1 - 0.2337\,\delta x_2 \\
& + 10.7022\,h_1 + 4.5356\,h_2 - 0.0018\,h_3 \\
& + 12.7013\,p_1 + 12.9883\,p_2 + 8.0038\,p_3 \\
(h_2)\quad 242.68 = {} & 0.4043\,\delta\varepsilon + 8.2523\,\delta x_1 + 7.5650\,\delta x_2 \\
& + 4.5356\,h_1 + 10.2960\,h_2 + 8.1944\,h_3 \\
& + 1.7866\,p_1 + 1.3667\,p_2 + 7.6671\,p_3 \\
(h_3)\quad 86.67 = {} & -4.5608\,\delta\varepsilon + 4.6963\,\delta x_1 + 10.5023\,\delta x_2 \\
& - 0.0018\,h_1 + 8.1944\,h_2 + 10.7071\,h_3 \\
& - 3.0812\,p_1 - 3.5347\,p_2 + 3.8855\,p_3 \\
(p_2)\quad 165.99 = {} & 19.3384\,\delta\varepsilon + 6.3978\,\delta x_1 - 3.4948\,\delta x_2 \\
& + 12.9883\,h_1 + 1.3667\,h_2 - 3.5347\,h_3 \\
& + 17.2795\,p_1 + 7.9106\,p_2 + 7.5423\,p_3 \\
(p_3)\quad 242.56 = {} & 7.3721\,\delta\varepsilon + 8.1831\,\delta x_1 + 3.4071\,\delta x_2 \\
& + 8.0038\,h_1 + 7.6671\,h_2 + 3.8855\,h_3 \\
& + 7.6127\,p_1 + 7.5423\,p_2 + 8.2019\,p_3
\end{aligned}
$$

16. By means of (ε) eliminate $\delta\varepsilon$ from each of the other equations, and these latter become

$$
\begin{aligned}
(x)\quad 202''.72 = {} & 6.5294\,\delta x_1 + 5.4577\,\delta x_2 + 3.4658\,h_1 + 8.1355\,h_2 \\
& + 6.0139\,h_3 + 1.1640\,p_1 + 0.8109\,p_2 + 6.0533\,p_3 \\
(h_1)\quad 111.41 = {} & 3.4658\,\delta x_1 + 2.6458\,\delta x_2 + 1.8531\,h_1 + 4.2731\,h_2 \\
& + 2.9588\,h_3 + 0.6243\,p_1 + 0.4349\,p_2 + 3.2183\,p_3 \\
(h_2)\quad 239.76 = {} & 8.1355\,\delta x_1 + 7.6504\,\delta x_2 + 4.2731\,h_1 + 10.2882\,h_2 \\
& + 8.2822\,h_3 + 1.4284\,p_1 + 0.9944\,p_2 + 7.5252\,p_3 \\
(h_3)\quad 119.57 = {} & 6.0139\,\delta x_1 + 9.5389\,\delta x_2 + 2.9588\,h_1 + 8.2822\,h_2 \\
& + 9.7166\,h_3 + 0.9593\,p_1 + 0.6652\,p_2 + 5.4866\,p_3 \\
(p_2)\quad 26.50 = {} & 0.8109\,\delta x_1 + 0.5900\,\delta x_2 + 0.4349\,h_1 + 0.9944\,h_2 \\
& + 0.6652\,h_3 + 0.1470\,p_1 + 0.1024\,p_2 + 0.7535\,p_3 \\
(p_3)\quad 189.38 = {} & 6.0533\,\delta x_1 + 4.9643\,\delta x_2 + 3.2183\,h_1 + 7.5252\,h_2 \\
& + 5.4866\,h_3 + 1.0815\,p_1 + 0.7535\,p_2 + 5.6139\,p_3
\end{aligned}
$$

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17. Again, by means of (x) eliminate δx_1 from each of the other equations, and we find

$$(h_1) \quad 3''.807 = -0.2512\,\delta x_2 + 0.0135\,h_1 - 0.0452\,h_2 - 0.2334\,h_3 + 0.0065\,p_1 + 0.0045\,p_2 + 0.0052\,p_3$$

$$(h_2) \quad -12.821 = 0.8502\,\delta x_2 - 0.0452\,h_1 + 0.1515\,h_2 + 0.7890\,h_3 - 0.0219\,p_1 - 0.0160\,p_2 - 0.0171\,p_3$$

$$(h_3) \quad -67.149 = 4.5120\,\delta x_2 - 0.2334\,h_1 + 0.7890\,h_2 + 4.1775\,h_3 - 0.1128\,p_1 - 0.0817\,p_2 - 0.0888\,p_3$$

$$(p_2) \quad 1.327 = -0.0878\,\delta x_2 + 0.0045\,h_1 - 0.0160\,h_2 - 0.0817\,h_3 + 0.0024\,p_1 + 0.0017\,p_2 + 0.0018\,p_3$$

$$(p_3) \quad 1.448 = -0.0955\,\delta x_2 + 0.0052\,h_1 - 0.0171\,h_2 - 0.0888\,h_3 + 0.0024\,p_1 + 0.0018\,p_2 + 0.0020\,p_3$$

18. Similarly, the equations of the second group are found to be

$$(n) \quad -171''.27 = 77.0000\,\delta n + 9.3938\,\delta y_1 - 1.2183\,\delta y_2 + 8.8463\,k_1 + 7.3034\,k_2 - 0.5927\,k_3 + 5.7519\,q_1 + 4.8755\,q_2 + 9.5583\,q_3$$

$$(y) \quad -166.33 = 93.9380\,\delta n + 12.7179\,\delta y_1 + 1.8907\,\delta y_2 + 11.2022\,k_1 + 11.0848\,k_2 + 2.6731\,k_3 + 7.0956\,q_1 + 5.9913\,q_2 + 12.7441\,q_3$$

$$(k_1) \quad -182.87 = 88.4630\,\delta n + 11.2022\,\delta y_1 - 0.3210\,\delta y_2 + 10.2978\,k_1 + 9.0964\,k_2 + 0.4061\,k_3 + 6.6370\,q_1 + 5.6163\,q_2 + 11.3346\,q_3$$

$$(k_2) \quad -89.07 = 73.0340\,\delta n + 11.0848\,\delta y_1 + 4.8266\,\delta y_2 + 9.0964\,k_1 + 10.7040\,k_2 + 5.4376\,k_3 + 5.5855\,q_1 + 4.6976\,q_2 + 10.9375\,q_3$$

$$(k_3) \quad +124.80 = -5.9270\,\delta n + 2.6731\,\delta y_1 + 10.4253\,\delta y_2 + 0.4061\,k_1 + 5.4376\,k_2 + 10.2929\,k_3 - 0.2497\,q_1 - 0.2643\,q_2 + 2.1788\,q_3$$

$$(q_2) \quad -107.02 = 48.7550\,\delta n + 5.9913\,\delta y_1 - 0.6614\,\delta y_2 + 5.6163\,k_1 + 4.6976\,k_2 - 0.2643\,k_3 + 3.6475\,q_1 + 3.0894\,q_2 + 6.0897\,q_3$$

$$(q_3) \quad -175.89 = 95.5830\,\delta n + 12.7441\,\delta y_1 + 1.3845\,\delta y_2 + 11.3346\,k_1 + 10.9375\,k_2 + 2.1788\,k_3 + 7.2804\,q_1 + 6.0897\,q_2 + 12.7981\,q_3$$

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19. By means of (n) eliminate δn from each of the other equations, and we have

$$
\begin{aligned}
(y)\quad 42''.61 = {} & 1.2578\,\delta y_1 + 3.3771\,\delta y_2 + 0.4100\,k_1 + 2.1748\,k_2 \\
& + 3.3962\,k_3 + 0.0785\,q_1 + 0.0433\,q_2 + 1.0833\,q_3 \\
(k_1)\quad 13.90 = {} & 0.4100\,\delta y_1 + 1.0787\,\delta y_2 + 0.1346\,k_1 + 0.7057\,k_2 \\
& + 1.0871\,k_3 + 0.0288\,q_1 + 0.0150\,q_2 + 0.3534\,q_3 \\
(k_2)\quad 73.38 = {} & 2.1748\,\delta y_1 + 5.9822\,\delta y_2 + 0.7057\,k_1 + 3.7767\,k_2 \\
& + 5.9998\,k_3 + 0.1298\,q_1 + 0.0732\,q_2 + 1.8715\,q_3 \\
(k_3)\quad 111.62 = {} & 3.3962\,\delta y_1 + 10.3315\,\delta y_2 + 1.0871\,k_1 + 5.9998\,k_2 \\
& + 10.2473\,k_3 + 0.1930\,q_1 + 0.1110\,q_2 + 2.9145\,q_3 \\
(q_2)\quad 1.42 = {} & 0.0433\,\delta y_1 + 0.1100\,\delta y_2 + 0.0150\,k_1 + 0.0732\,k_2 \\
& + 0.1110\,k_3 + 0.0055\,q_1 + 0.0023\,q_2 + 0.0375\,q_3 \\
(q_3)\quad 36.72 = {} & 1.0833\,\delta y_1 + 2.8969\,\delta y_2 + 0.3534\,k_1 + 1.8715\,k_2 \\
& + 2.9145\,k_3 + 0.0684\,q_1 + 0.0375\,q_2 + 0.9330\,q_3
\end{aligned}
$$

20. Again, eliminating δy_1 by means of (y) we find

$$
\begin{aligned}
(k_1)\quad 0''.009 = {} & -0.0221\,\delta y_2 + 0.0010\,k_1 - 0.0032\,k_2 - 0.0200\,k_3 \\
& + 0.0032\,q_1 + 0.0009\,q_2 + 0.0003\,q_3 \\
(k_2)\quad -0.301 = {} & 0.1430\,\delta y_2 - 0.0032\,k_1 + 0.0162\,k_2 + 0.1274\,k_3 \\
& - 0.0059\,q_1 - 0.0017\,q_2 - 0.0016\,q_3 \\
(k_3)\quad -3.443 = {} & 1.2129\,\delta y_2 - 0.0200\,k_1 + 0.1274\,k_2 + 1.0769\,k_3 \\
& - 0.0189\,q_1 - 0.0059\,q_2 - 0.0105\,q_3 \\
(q_2)\quad -0.045 = {} & -0.0062\,\delta y_2 + 0.0009\,k_1 - 0.0017\,k_2 - 0.0059\,k_3 \\
& + 0.0028\,q_1 + 0.0008\,q_2 + 0.0002\,q_3 \\
(q_3)\quad +0.017 = {} & -0.0116\,\delta y_2 + 0.0003\,k_1 - 0.0016\,k_2 - 0.0105\,k_3 \\
& + 0.0008\,q_1 + 0.0002\,q_2 + 0.0000\,q_3
\end{aligned}
$$

21. From the equations remaining in the two groups after the elimination of $\delta\epsilon$, δn, δx_1, δy_1, it will be easy, when approximate values of the mass and mean longitude of the disturbing planet have been found, to deduce the final equations for determining these quantities more accurately by the method of minimum squares.

It may be observed, however, that the equations in each group are very nearly identical with each other, and therefore two final equations may be formed by simply adding together the several equations of each

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group, after giving the unknown quantities the same sign in them all. Thus we find

$$\begin{aligned} 86''.552 = &-5.7967\,\delta x_2 + 0.3018\,h_1 - 1.0188\,h_2 - 5.3704\,h_3 \\ &+ 0.1460\,p_1 + 0.1056\,p_2 + 0.1149\,p_3 \end{aligned}$$

$$\begin{aligned} 3.725 = &-1.3958\,\delta y_2 + 0.0254\,k_1 - 0.1501\,k_2 - 1.2407\,k_3 \\ &+ 0.0316\,q_1 + 0.0095\,q_2 + 0.0127\,q_3 \end{aligned}$$

22. If in the expressions before given for δx_2 and δy_2 we substitute $e = 0.046679$ and $\varepsilon - \varpi = 50^\circ\ 15'.8$, we obtain

$$\begin{aligned} \delta x_2 = &\ 0.007460\,\delta x_1 + 0.008974\,\delta y_1 \\ \delta y_2 = &-0.008974\,\delta x_1 + 0.007460\,\delta y_1 \end{aligned}$$

Substituting these values in the equations (x) and (y), and in those just found, it may be seen that by adding to the latter equations

$$\begin{aligned} &0.006768\,(x) + 0.040287\,(y) \\ \text{and} \quad &-0.001869\,(x) + 0.008187\,(y) \text{ respectively,} \end{aligned}$$

δx_1 and δy_1 will be eliminated, and we shall obtain the following equations:

$$\begin{aligned} (1) \quad 89''.641 = &\ 0.3252\,h_1 - 0.9637\,h_2 - 5.3297\,h_3 \\ &+ 0.0165\,k_1 + 0.0876\,k_2 + 0.1368\,k_3 \\ &+ 0.1539\,p_1 + 0.1111\,p_2 + 0.1559\,p_3 \\ &+ 0.0032\,q_1 + 0.0017\,q_2 + 0.0436\,q_3 \end{aligned}$$

$$\begin{aligned} (2) \quad 3.695 = &-0.0065\,h_1 - 0.0152\,h_2 - 0.0112\,h_3 \\ &+ 0.0288\,k_1 - 0.1323\,k_2 - 1.2129\,k_3 \\ &- 0.0022\,p_1 - 0.0015\,p_2 - 0.0113\,p_3 \\ &+ 0.0323\,q_1 + 0.0099\,q_2 + 0.0215\,q_3 \end{aligned}$$

23. These equations would be sufficient for determining the mass of the disturbing planet and its longitude at the epoch, if the eccentricity of the orbit were neglected. We will now proceed to find equations from the ancient observations for determining the eccentricity and longitude of the perihelion.

The equations of condition given by the ancient observations are the following:—

$$\begin{aligned} 62''.6 = &\ \delta\varepsilon - 0.8776\,\delta x_1 + 0.5402\,\delta x_2 + 0.8712\,h_1 + 0.5180\,h_2 \\ -39.31\,&\delta n - 0.4795\,\delta y_1 + 0.8415\,\delta y_2 + 0.4909\,k_1 + 0.8554\,k_2 \\ &+ 0.0314\,h_2 - 0.9999\,p_1 - 0.8640\,p_2 - 0.5055\,p_3 \\ &+ 0.9995\,k_3 + 0.0145\,q_1 - 0.5035\,q_2 - 0.8628\,q_3 \end{aligned}$$

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$$
\begin{aligned}
84''.5 = {} & \delta\epsilon + 0.4975\,\delta x_1 - 0.5050\,\delta x_2 + 0.0288\,k_1 - 0.9984\,k_2 \\
-32.30 & \delta\pi - 0.8675\,\delta y_1 - 0.8631\,\delta y_2 + 0.9996\,k_1 + 0.0573\,k_2 \\
& - 0.0860\,k_3 - 0.8534\,p_1 - 0.5456\,p_2 + 0.8220\,p_3 \\
& - 0.9963\,k_3 - 0.5213\,q_1 - 0.8380\,q_2 - 0.5695\,q_3
\end{aligned}
$$

$$
\begin{aligned}
67.2 = {} & \delta\epsilon + 0.6732\,\delta x_1 - 0.0935\,\delta x_2 - 0.1120\,k_1 - 0.9749\,k_2 \\
-31.34 & \delta\pi - 0.7394\,\delta y_1 - 0.9956\,\delta y_2 + 0.9937\,k_1 - 0.2227\,k_2 \\
& + 0.3305\,k_3 - 0.8105\,p_1 - 0.4912\,p_2 + 0.9206\,p_3 \\
& - 0.9438\,k_3 - 0.5857\,q_1 - 0.8711\,q_2 - 0.3905\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-51.8 = {} & \delta\epsilon - 0.2616\,\delta x_1 - 0.8631\,\delta x_2 - 0.9649\,k_1 + 0.8618\,k_2 \\
-19.59 & \delta\pi + 0.9652\,\delta y_1 - 0.5050\,\delta y_2 - 0.2627\,k_1 + 0.5073\,k_2 \\
& - 0.6982\,k_3 - 0.0023\,p_1 + 0.2650\,p_2 - 0.5090\,p_3 \\
& - 0.7159\,k_3 - 1.0000\,q_1 - 0.9642\,q_2 + 0.8607\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-43.2 = {} & \delta\epsilon - 0.4741\,\delta x_1 - 0.5505\,\delta x_2 - 0.9154\,k_1 + 0.6758\,k_2 \\
-18.58 & \delta\pi + 0.8805\,\delta y_1 - 0.8348\,\delta y_2 - 0.4025\,k_1 + 0.7371\,k_2 \\
& - 0.3220\,k_3 + 0.0787\,p_1 + 0.3291\,p_2 - 0.6814\,p_3 \\
& - 0.9467\,k_3 - 0.9969\,q_1 - 0.9443\,q_2 + 0.7319\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-50.1 = {} & \delta\epsilon - 0.6430\,\delta x_1 - 0.1731\,\delta x_2 - 0.8543\,k_1 + 0.4599\,k_2 \\
-1\cdot68 & \delta\pi + 0.7659\,\delta y_1 - 0.9849\,\delta y_2 - 0.5198\,k_1 + 0.88\cdot9\,k_2 \\
& + 0.0686\,k_3 + 0.1510\,p_1 + 0.3848\,p_2 - 0.8085\,p_3 \\
& - 0.99\cdot6\,k_3 - 0.9885\,q_1 - 0.9230\,q_2 + 0.5885\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-3\cdot\cdot3 = {} & \delta\epsilon - 0.9492\,\delta x_1 + 0.8021\,\delta x_2 - 0.6189\,k_1 - 0.234\cdot\,k_2 \\
-15\cdot5 & \delta\pi + 0.3145\,\delta y_1 - 0.59\cdot2\,\delta y_2 - 0.\cdot855\,k_1 + 0.9\cdot22\,k_2 \\
& + 0.9085\,k_3 + 0.3396\,p_1 + 0.528\cdot\,p_2 - 0.9\cdot359\,p_3 \\
& - 0.41\cdot9\,k_3 - 0.9406\,q_1 - 0.8488\,q_2 - 0.1\cdot\cdot0\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-\cdot\cdot\cdot5 = {} & \delta\epsilon - 0.9985\,\delta x_1 + 0.9942\,\delta x_2 - 0.4128\,k_1 - 0.65\cdot1\,k_2 \\
-15\cdot\cdot & \delta\pi - 0.\cdot\cdot5\cdot\,\delta y_1 + 0.1\cdot\cdot4\,\delta y_2 - 0.9\cdot\cdot\,k_1 + 0.\cdot\cdot\,k_2 \\
& + 0.\cdot\cdot5\cdot\,k_3 + 0.\cdot\cdot\,p_1 + 0.\cdot\cdot\,p_2 - 0.\cdot\cdot\,p_3 \\
& + 0.\cdot\cdot\,k_3 - 0.\cdot\cdot\,q_1 - 0.\cdot\cdot\,q_2 - 0.\cdot\cdot\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-\cdot\cdot4 = {} & \delta\epsilon - 0.\cdot\cdot\,\delta x_1 + 0.\cdot\cdot\,\delta x_2 - 0.\cdot\cdot\,k_1 - 0.\cdot\cdot\,k_2 \\
-1\cdot\cdot & \delta\pi - 0.\cdot\cdot\,\delta y_1 + 0.\cdot\cdot\,\delta y_2 - 0.\cdot\cdot\,k_1 + 0.\cdot\cdot\,k_2 \\
& + 0.\cdot\cdot\,k_3 + 0.\cdot\cdot\,p_1 + 0.\cdot\cdot\,p_2 - 0.\cdot\cdot\,p_3 \\
& + 0.\cdot\cdot\,k_3 - 0.\cdot\cdot\,q_1 - 0.\cdot\cdot\,q_2 - 0.\cdot\cdot\,q_3
\end{aligned}
$$

24. From each of these equations eliminate k_3, p_3, q_3, and k_3, by means of the equations (3), (4), (5), and (6) before found, and we have the following:—

$$
\begin{aligned}
-\cdot\cdot\cdot\cdot = {} & \cdot\cdot\cdot\cdot\,\delta x_1 - 0.\cdot\cdot\,k_1 - 1.\cdot\cdot\,k_1 + \cdot\cdot\cdot\cdot\,k_2 \\
-\cdot\cdot\cdot\cdot & \delta\pi - 0.\cdot\cdot\,\delta y_1 - 0.\cdot\cdot\,\delta y_2 + 1.\cdot\cdot\,k_1 - 0.\cdot\cdot\,k_2 \\
& - 1.\cdot\cdot\,p_1 - 0.\cdot\cdot\,p_2 + 0.\cdot\cdot\,p_3 \\
& - 0.\cdot\cdot\,q_1 - 0.\cdot\cdot\,q_2 - 0.\cdot\cdot\,q_3
\end{aligned}
$$

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$$
\begin{aligned}
-105''.2 = &-0.4681\,\delta x_2 - 0.7311\,h_1 - 1.2776\,h_2 - 0.0609\,h_3 \\
&-9.6249\,\delta y_2 + 3.7087\,k_1 - 2.1926\,k_2 - 9.5426\,k_3 \\
&-1.7765\,p_1 - 1.4924\,p_2 + 0.2786\,p_3 \\
&+1.6997\,q_1 + 1.1014\,q_2 + 0.7934\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-126.1 = &-0.2035\,\delta x_2 - 0.9653\,h_1 - 1.4730\,h_2 + 0.1937\,h_3 \\
&-9.7719\,\delta y_2 + 3.5895\,k_1 - 2.5827\,k_2 - 9.5123\,k_3 \\
&-1.7649\,p_1 - 1.4598\,p_2 + 0.2133\,p_3 \\
&+1.5629\,q_1 + 1.0070\,q_2 + 0.8437\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-199.1 = &-0.1917\,\delta x_2 - 1.3218\,h_1 + 1.5284\,h_2 + 0.0260\,h_3 \\
&-9.8232\,\delta y_2 + 0.8943\,k_1 - 3.4359\,k_2 - 9.9270\,k_3 \\
&-0.7901\,p_1 - 0.5885\,p_2 - 0.3497\,p_3 \\
&+0.2540\,q_1 + 0.1607\,q_2 + 0.4028\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-174.7 = &\;\;0.2985\,\delta x_2 - 1.1595\,h_1 + 1.6072\,h_2 + 0.5979\,h_3 \\
&-9.5788\,\delta y_2 + 0.7062\,k_1 - 2.9425\,k_2 - 9.5877\,k_3 \\
&-0.6712\,p_1 - 0.4970\,p_2 - 0.3251\,p_3 \\
&+0.1946\,q_1 + 0.1238\,q_2 + 0.3277\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-166.7 = &\;\;0.8171\,\delta x_2 - 1.0088\,h_1 + 1.6018\,h_2 + 1.1442\,h_3 \\
&-9.1122\,\delta y_2 + 0.5586\,k_1 - 2.4890\,k_2 - 9.0258\,k_3 \\
&-0.5688\,p_1 - 0.4203\,p_2 - 0.2956\,p_3 \\
&+0.1498\,q_1 + 0.0958\,q_2 + 0.2658\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-114.2 = &\;\;2.0482\,\delta x_2 - 0.6027\,h_1 + 1.2894\,h_2 + 2.2661\,h_3 \\
&-6.6781\,\delta y_2 + 0.2576\,k_1 - 1.3421\,k_2 - 6.4080\,k_3 \\
&-0.3256\,p_1 - 0.2384\,p_2 - 0.1971\,p_3 \\
&+0.0628\,q_1 + 0.0419\,q_2 + 0.1298\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-\;72.4 = &\;\;2.2815\,\delta x_2 - 0.3786\,h_1 + 0.9257\,h_2 + 2.3601\,h_3 \\
&-4.4181\,\delta y_2 + 0.1283\,k_1 - 0.7339\,k_2 - 4.1495\,k_3 \\
&-0.1957\,p_1 - 0.1428\,p_2 - 0.1286\,p_3 \\
&+0.0283\,q_1 + 0.0198\,q_2 + 0.0671\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-\;42.0 = &\;\;2.1139\,\delta x_2 - 0.2652\,h_1 + 0.6985\,h_2 + 2.1241\,h_3 \\
&-3.1027\,\delta y_2 + 0.0772\,k_1 - 0.4646\,k_2 - 2.8790\,k_3 \\
&-0.1348\,p_1 - 0.0984\,p_2 - 0.0924\,p_3 \\
&+0.0154\,q_1 + 0.0114\,q_2 + 0.0412\,q_3
\end{aligned}
$$

25. The largest terms depending on the eccentricity of the disturbing planet occur in p_3, q_3; it will be proper, therefore, to combine the above equations in such a manner that these quantities may acquire the largest coefficients possible. This will be done by multiplying each equation by a

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quantity nearly proportional to the coefficient of each of the unknown quantities p_3 and q_3, and adding together the several results. It was thought unsafe to employ the first of the above equations, since it is derived from the single observation of Flamsteed made in 1690, twenty-two years anterior to any other observation.

Hence the equation for finding p_3 may be formed by multiplying the above equations, taken in order, by

$$-0{\cdot}8,\ -0{\cdot}6,\ +1{\cdot}0,\ +1{\cdot}0,\ +0{\cdot}9,\ +0{\cdot}6,\ +0{\cdot}4,\ +0{\cdot}3,$$

beginning with the second; and the equation for q_3 by multiplying the same equations by

$$0{\cdot}1,\ 1{\cdot}0,\ 0{\cdot}5,\ 0{\cdot}4,\ 0{\cdot}3,\ 0{\cdot}2,\ 0{\cdot}1,\ 0{\cdot}1.$$

Hence we obtain

$$\begin{aligned}
-474''{\cdot}1 = \quad & 4{\cdot}114\,\delta x_2 - 2{\cdot}817\,h_1 + 7{\cdot}837\,h_2 + 4{\cdot}528\,h_3 \\
& -20{\cdot}745\,\delta y_2 - 2{\cdot}789\,k_1 - 6{\cdot}551\,k_2 - 20{\cdot}666\,k_3 \\
& +0{\cdot}193\,p_1 + 0{\cdot}377\,p_2 - 1{\cdot}489\,p_3 \\
& -1{\cdot}660\,q_1 - 1{\cdot}078\,q_2 - 0{\cdot}054\,q_3 \\
-485{\cdot}0 = \quad & 0{\cdot}446\,\delta x_2 - 3{\cdot}308\,h_1 - 0{\cdot}442\,h_2 + 1{\cdot}629\,h_3 \\
& -32{\cdot}961\,\delta y_2 + 8{\cdot}267\,k_1 - 8{\cdot}805\,k_2 - 32{\cdot}546\,k_3 \\
& -4{\cdot}473\,p_1 - 3{\cdot}643\,p_2 + 0{\cdot}037\,p_3 \\
& +3{\cdot}530\,q_1 + 2{\cdot}278\,q_2 + 2{\cdot}086\,q_3
\end{aligned}$$

26. Eliminate δx_2 and δy_2 from these equations by means of (x) and (y) and they become

$$\begin{aligned}
(3) \quad -476{\cdot}7 = \quad & -2''{\cdot}930\,h_1 + 7{\cdot}572\,h_2 + 4{\cdot}332\,h_3 \\
& -2{\cdot}751\,k_1 - 6{\cdot}348\,k_2 - 20{\cdot}350\,k_3 \\
& +0{\cdot}155\,p_1 + 0{\cdot}350\,p_2 - 1{\cdot}686\,p_3 \\
& -1{\cdot}653\,q_1 - 1{\cdot}074\,q_2 + 0{\cdot}047\,q_3 \\
(4) \quad -485{\cdot}9 = \quad & -3{\cdot}463\,h_1 - 0{\cdot}805\,h_2 + 1{\cdot}360\,h_3 \\
& +8{\cdot}345\,k_1 - 8{\cdot}391\,k_2 - 31{\cdot}900\,k_3 \\
& -4{\cdot}525\,p_1 - 3{\cdot}679\,p_2 - 0{\cdot}233\,p_3 \\
& +3{\cdot}545\,q_1 + 2{\cdot}286\,q_2 + 2{\cdot}292\,q_3
\end{aligned}$$

These equations, with (1) and (2) of article 22, suffice for the solution of our problem.

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27. Eliminate the left-hand members from equations (2), (3), (4), by means of equation (1), and we have

$$\begin{aligned}
0 = {} & 0{\cdot}4819\,h_1 - 0{\cdot}5950\,h_2 - 5{\cdot}0570\,h_3 + 0{\cdot}2063\,p_1 + 0{\cdot}1475\,p_2 + 0{\cdot}4300\,p_3 \\
& - 0{\cdot}6812\,k_1 + 3{\cdot}2982\,k_2 + 29{\cdot}5618\,k_3 - 0{\cdot}7804\,q_1 - 0{\cdot}2375\,q_2 - 0{\cdot}4789\,q_3 \\
0 = {} & -1{\cdot}2005\,h_1 + 2{\cdot}4466\,h_2 - 24{\cdot}0122\,h_3 + 0{\cdot}9735\,p_1 + 0{\cdot}9412\,p_2 - 0{\cdot}8575\,p_3 \\
& - 2{\cdot}6633\,k_1 - 5{\cdot}8825\,k_2 - 19{\cdot}6219\,k_3 - 1{\cdot}6362\,q_1 - 1{\cdot}0648\,q_2 + 0{\cdot}2791\,q_3 \\
0 = {} & -1{\cdot}7003\,h_1 - 6{\cdot}0294\,h_2 - 27{\cdot}5295\,k_3 - 3{\cdot}6908\,p_1 - 3{\cdot}0772\,p_2 + 0{\cdot}6118\,p_3 \\
& + 8{\cdot}4344\,k_1 - 7{\cdot}9162\,k_2 - 31{\cdot}1583\,k_3 + 3{\cdot}5621\,q_1 + 2{\cdot}2954\,q_2 + 2{\cdot}5285\,q_3
\end{aligned}$$

28. If now we put $\varepsilon - \varepsilon' = \theta$ and $\varepsilon - \varpi = \beta$, it is easily seen that

$$\frac{h_1}{m'} = -36''{\cdot}99 \sin\theta \qquad \frac{h_2}{m'} = 58''{\cdot}97 \sin 2\theta$$

$$\frac{k_1}{m'} = -36{\cdot}99 \cos\theta \qquad \frac{k_2}{m'} = 58{\cdot}97 \cos 2\theta$$

$$\frac{h_3}{m'} = 5{\cdot}80 \sin 3\theta + 0{\cdot}007460\,\frac{p_3}{m'} + 0{\cdot}008974\,\frac{q_3}{m'}$$

$$\frac{k_3}{m'} = 5{\cdot}80 \cos 3\theta - 0{\cdot}008974\,\frac{p_3}{m'} + 0{\cdot}007460\,\frac{q_3}{m'}$$

$$\frac{p_1}{m'} = 0{\cdot}18 \sin(\theta-\beta) - 0{\cdot}046247\left\{\frac{p_3}{m'}\cos 2\theta - \frac{q_3}{m'}\sin 2\theta\right\}$$

$$\frac{q_1}{m'} = -\,0{\cdot}18 \cos(\theta-\beta) + 0{\cdot}046247\left\{\frac{p_3}{m'}\sin 2\theta + \frac{q_3}{m'}\cos 2\theta\right\}$$

$$\frac{p_2}{m'} = 24{\cdot}91 \sin(2\theta-\beta) + 0{\cdot}13055\left\{\frac{p_3}{m'}\cos\theta - \frac{q_3}{m'}\sin\theta\right\}$$

$$\frac{q_2}{m'} = 24{\cdot}91 \cos(2\theta-\beta) + 0{\cdot}13055\left\{\frac{p_3}{m'}\sin\theta + \frac{q_3}{m'}\cos\theta\right\}$$

29. Substituting these expressions in the equations of article 27, and putting for β its value $50^\circ\ 15'{\cdot}8$, we obtain, after a slight reduction,

$$\begin{aligned}
0 = {} & -(1{\cdot}24782)\sin\theta + (1{\cdot}40248)\cos\theta - (1{\cdot}57155)\sin 2\theta + (2{\cdot}27388)\cos 2\theta \\
& - (1{\cdot}46746)\sin 3\theta + (2{\cdot}23430)\cos 3\theta + (9{\cdot}10380)\,\frac{p_3}{m'} - (9{\cdot}48254)\,\frac{q_3}{m'} \\
& + (8{\cdot}28455)\left\{\frac{p_3}{m'}\cos\theta - \frac{q_3}{m'}\sin\theta\right\} - (8{\cdot}49138)\left\{\frac{p_3}{m'}\sin\theta + \frac{q_3}{m'}\cos\theta\right\} \\
& - (7{\cdot}97958)\left\{\frac{p_3}{m'}\cos 2\theta - \frac{q_3}{m'}\sin 2\theta\right\} - (8{\cdot}55742)\left\{\frac{p_3}{m'}\sin 2\theta + \frac{q_3}{m'}\cos 2\theta\right\}
\end{aligned}$$

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$$0 = (1\cdot65083)\sin\theta+(1\cdot99378)\cos\theta+(2\cdot14259)\sin 2\theta-(2\cdot58192)\cos 2\theta$$
$$-(2\cdot14400)\sin 3\theta-(2\cdot05631)\cos 3\theta-(9\cdot93475)\frac{p_3}{m'}-(8\cdot91803)\frac{q_3}{m'}$$
$$+(9\cdot08947)\left\{\frac{p_3}{m'}\cos\theta-\frac{q_3}{m'}\sin\theta\right\}-(9\cdot14306)\left\{\frac{p_3}{m'}\sin\theta+\frac{q_3}{m'}\cos\theta\right\}$$
$$-(8\cdot65341)\left\{\frac{p_3}{m'}\cos 2\theta-\frac{q_3}{m'}\sin 2\theta\right\}-(8\cdot87892)\left\{\frac{p_3}{m'}\sin 2\theta+\frac{q_3}{m'}\cos 2\theta\right\}$$

$$0 = (1\cdot79213)\sin\theta-(2\cdot49403)\cos\theta-(2\cdot55700)\sin 2\theta-(2\cdot56972)\cos 2\theta$$
$$-(2\cdot20337)\sin 3\theta-(2\cdot25714)\cos 3\theta+(9\cdot83632)\frac{p_3}{m'}+(0\cdot31156)\frac{q_3}{m'}$$
$$-(9\cdot60395)\left\{\frac{p_3}{m'}\cos\theta-\frac{q_3}{m'}\sin\theta\right\}+(9\cdot47665)\left\{\frac{p_3}{m'}\sin\theta+\frac{q_3}{m'}\cos\theta\right\}$$
$$+(9\cdot23220)\left\{\frac{p_3}{m'}\cos 2\theta-\frac{q_3}{m'}\sin 2\theta\right\}+(9\cdot21679)\left\{\frac{p_3}{m'}\sin 2\theta+\frac{q_3}{m'}\cos 2\theta\right\}$$

where the numbers enclosed within parentheses denote the logarithms of the corresponding coefficients.

30. These equations may be rapidly solved by approximation. The coefficients of $\frac{p_3}{m'}$ and $\frac{q_3}{m'}$ in the first equation being small, we may find from it an approximate value of θ, the substitution of which in the second and third equations will give approximate values of $\frac{p_3}{m'}$ and $\frac{q_3}{m'}$. By means of these a more accurate value of θ may be found from the first equation, and the process being repeated, will enable us to satisfy all the equations as nearly as we please.

Thus we find $\theta = -51^\circ\ 30'$, $\frac{p_3}{m'} = 271''\cdot57$, $\frac{q_3}{m'} = -207''\cdot24$.

Now ε is known and $= 217^\circ\ 55'$ $\therefore \varepsilon' = 269^\circ\ 25'$ the mean longitude of the disturbing planet at the epoch 1810·328. The sidereal motion in 36 synodic periods of *Uranus* $= 55^\circ 12'$, precession $= 30'$, $\therefore$ mean longitude at the time 1846·762, or October 6, 1846, $= 325^\circ\ 7'$.

Also, the analytical expressions for $\frac{p_3}{m'}$ and $\frac{q_3}{m'}$ are

$$\frac{p_3}{m'} = 48''\cdot55\sin(3\theta-\beta)-93''\cdot01\,\varepsilon'\sin(3\theta-\beta')$$

$$\frac{q_3}{m'} = 48\cdot55\cos(3\theta-\beta)-93\cdot01\,\varepsilon'\cos(3\theta-\beta')$$

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where $\varepsilon - \varpi' = \beta'$. Equating these to the values given above, we find $\varepsilon' = 3{\cdot}2206$, $\beta' = 262^\circ\,28'$, and $\therefore\ \varpi' = 315^\circ\,27'$. Hence longitude of perihelion in 1846 $= 315^\circ\,57'$.

Lastly, substituting the values just obtained in equation (1), we find $m' = 0{\cdot}82816$.

31. Hence the values of the mass and elements of the orbit of the disturbing planet, resulting from the first hypothesis as to the mean distance, are the following:—

$$\frac{a}{a'} = 0{\cdot}5$$

Mean Long. of the Planet, October 6, 1846	$325^\circ\ 7''$
Longitude of the Perihelion	315 57
Eccentricity of the Orbit	0·16103
Mass (that of the Sun being 1)	0·0001656

These are the results which I communicated to the Astronomer Royal in October 1845.

32. I next entered upon a similar investigation, founded on the assumption that the mean distance was about $\frac{1}{30}$th part less than before, so that $\frac{a}{a'}$ or $\alpha = \sin 31^\circ = 0{\cdot}515$. The method employed was, in principle, exactly the same as that given before; but the numerical calculations were somewhat shortened by a few alterations in the process, which had been suggested by my previous solution.

33. Assuming then that $\alpha = \sin 31^\circ$, the values of the quantities b, $\alpha \frac{db}{d\alpha}$, $\alpha^2 \frac{d^2 b}{d\alpha^2}$, will be

$\log b_0 = 0{\cdot}33385$	$\log \alpha \frac{db_0}{d\alpha} = 9{\cdot}57333$	$\log \alpha^2 \frac{d^2 b_0}{d\alpha^2} = 9{\cdot}82911$
$\log b_1 = 9{\cdot}76106$	$\log \alpha \frac{db_1}{d\alpha} = 9{\cdot}86149$	$\log \alpha^2 \frac{d^2 b_1}{d\alpha^2} = 9{\cdot}76573$
$\log b_2 = 9{\cdot}35361$	$\log \alpha \frac{db_2}{d\alpha} = 9{\cdot}71359$	$\log \alpha^2 \frac{d^2 b_2}{d\alpha^2} = 9{\cdot}92466$
$\log b_3 = 8{\cdot}98918$	$\log \alpha \frac{db_3}{d\alpha} = 9{\cdot}50854$	$\log \alpha^2 \frac{d^2 b_3}{d\alpha^2} = 9{\cdot}91563$

Hence, by means of the formulæ given before, the principal inequalities of the mean longitude of *Uranus*, produced by the action of a planet whose mass

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is $\frac{m'}{5000}$, that of the sun being unity, and the eccentricity of whose orbit is $\frac{e'}{20}$, may be found to be the following:—

$$\begin{aligned}
&-42''.33\, m' \sin \{nt-n't+\epsilon-\epsilon'\}\\
&+76.55\, m' \sin 2\{nt-n't+\epsilon-\epsilon'\}\\
&+\ 7.25\, m' \sin 3\{nt-n't+\epsilon-\epsilon'\}\\
&+\ 2.34\, m' \sin \{n't+\epsilon'-\varpi\}\\
&-\ 4.74\, m'e' \sin \{n't+\epsilon'-\varpi'\}\\
&+41.72\, m' \sin \{nt-2n't+\epsilon-2\epsilon'+\varpi\}\\
&-16.47\, m'e' \sin \{nt-2n't+\epsilon-2\epsilon'+\varpi'\}\\
&+33.93\, m' \sin \{2nt-3n't+2\epsilon-3\epsilon'+\varpi\}\\
&-63.41\, m'e' \sin \{2nt-3n't+2\epsilon-3\epsilon'+\varpi'\}
\end{aligned}$$

To these we may add the following, which are of two dimensions in terms of the eccentricities:—

$$\begin{aligned}
&+0''.40\, m' \sin 3\{nt-n't+\epsilon-\epsilon'\}\\
&-0.74\, m'e' \sin \{3(nt-n't+\epsilon-\epsilon')-\varpi+\varpi'\}
\end{aligned}$$

34. Now, on our present assumption, $n = 13^\circ\,0'.6$, $n' = 4^\circ\,48'.5$, $n-n' = 8^\circ\,12'.1$, $n-2n' = 3^\circ\,23'.6$, $2n-3n' = 11^\circ\,35'.7$.

Hence the equations of condition given by the modern observations will be of the form

$$\begin{aligned}
c'' = {} & \delta\epsilon + \delta x_1 \cos\{13^\circ\ 0'.5\}\,t + \delta x_2 \cos\{26^\circ\ 1'.0\}\,t\\
& + t\delta n + \delta y_1 \sin\{13\ \ 0.5\}\,t + \delta y_2 \sin\{26\ \ 1.0\}\,t\\
& + h_1 \cos\{\ 8\ 12.1\}\,t + h_2 \cos\{16\ 24.2\}\,t + h_3 \cos\{24^\circ\ 36'.3\}\,t\\
& + k_1 \sin\{\ 8\ 12.1\}\,t + k_2 \sin\{16\ 24.2\}\,t + k_3 \sin\{24\ 36.3\}\,t\\
& + p_1 \cos\{\ 4\ 48.5\}\,t + p_2 \cos\{\ 3\ 23.6\}\,t + p_3 \cos\{11\ 35.7\}\,t\\
& + q_1 \sin\{\ 4\ 48.5\}\,t + q_2 \sin\{\ 3\ 23.6\}\,t + q_3 \sin\{11\ 35.7\}\,t
\end{aligned}$$

35. Treating these equations of condition in the same manner as before, the equations in the first group, derived from them, are found to be the following:—

$$\begin{aligned}
(\epsilon)\quad 151''.48 = {} & 21.0000\,\delta\epsilon + 6.0670\,\delta x_1 - 4.4358\,\delta x_2\\
& +13.9515\,h_1 + 0.9471\,h_2 - 4.5965\,h_3\\
& +18.3916\,p_1 + 19.6752\,p_2 + 8.4184\,p_3\\
(x)\quad 246.48 = {} & 6.0670\,\delta\epsilon + 8.2821\,\delta x_1 + 4.1762\,\delta x_2\\
& + 7.3540\,h_1 + 8.3027\,h_2 + 5.0961\,h_3\\
& + 6.5793\,p_1 + 6.3319\,p_2 + 8.0850\,p_3
\end{aligned}$$

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$$
\begin{aligned}
(h_1)\quad 207''.58 = {} & 13.9515\,\delta\varepsilon + 7.3540\,\delta x_1 - 0.4177\,\delta x_2 \\
& + 10.9735\,h_1 + 4.6775\,h_2 - 0.0005\,h_3 \\
& + 12.8697\,p_1 + 13.4050\,p_2 + 8.4781\,p_3 \\
(h_2)\quad 245.17 = {} & 0.9471\,\delta\varepsilon + 8.3027\,\delta x_1 + 7.2362\,\delta x_2 \\
& + 4.6775\,h_1 + 10.0259\,h_2 + 8.3220\,h_3 \\
& + 2.3661\,p_1 + 1.6727\,p_2 + 7.3073\,p_3 \\
(h_3)\quad 103.48 = {} & -4.5965\,\delta\varepsilon + 5.0961\,\delta x_1 + 10.5558\,\delta x_2 \\
& - 0.0005\,h_1 + 8.3220\,h_2 + 10.9749\,h_3 \\
& - 2.8935\,p_1 - 3.7316\,p_2 + 3.5852\,p_3
\end{aligned}
$$

36. Similarly the equations in the second group are

$$
\begin{aligned}
(n)\quad -171''.27 = {} & 77.0000\,\delta n + 9.3938\,\delta y_1 - 1.2183\,\delta y_2 \\
& + 8.7355\,k_1 + 7.6213\,k_2 - 0.0590\,k_3 \\
& + 5.9764\,q_1 + 4.3875\,q_2 + 9.6152\,q_3 \\
(y)\quad -166.33 = {} & 93.9380\,\delta n + 12.7179\,\delta y_1 + 1.8907\,\delta y_2 \\
& + 11.0393\,k_1 + 11.3717\,k_2 + 3.3196\,k_3 \\
& + 7.3747\,q_1 + 5.3825\,q_2 + 12.6816\,q_3 \\
(k_1)\quad -181.31 = {} & 87.3550\,\delta n + 11.0393\,\delta y_1 - 0.3758\,\delta y_2 \\
& + 10.0264\,k_1 + 9.2740\,k_2 + 0.9476\,k_3 \\
& + 6.8054\,q_1 + 4.9866\,q_2 + 11.1971\,q_3 \\
(k_2)\quad -99.51 = {} & 76.2130\,\delta n + 11.3717\,\delta y_1 + 4.4810\,\delta y_2 \\
& + 9.2740\,k_1 + 10.9740\,k_2 + 5.6294\,k_3 \\
& + 6.0523\,q_1 + 4.3916\,q_2 + 11.0843\,q_3 \\
(k_3)\quad 113.14 = {} & -0.5900\,\delta n + 3.3196\,\delta y_1 + 10.2112\,\delta y_2 \\
& + 0.9476\,k_1 + 5.6294\,k_2 + 10.0251\,k_3 \\
& + 0.1746\,q_1 + 0.0454\,q_2 + 2.4791\,q_3
\end{aligned}
$$

37. The equations (p_2), (p_3) of the first group, and (q_2), (q_3) of the second, were not formed, as our previous solution shewed that when $\delta\varepsilon$, δn, δx_1, and δy_1, were eliminated, the coefficients of the remaining unknown quantities in these equations would be extremely small. It will be preferable to combine the equations (h_1), (h_2), (h_3), and (k_1), (k_2), (k_3) before, instead of after, the elimination of $\delta\varepsilon$, δn, δx_1, and δy_1, from them. If then we change the sign of the third equation in each group, and add it to the fourth and fifth, we obtain

$$
\begin{aligned}
141''.07 = {} & -17.6009\,\delta\varepsilon + 6.0448\,\delta x_1 + 18.2097\,\delta x_2 \\
& - 6.2965\,h_1 + 13.6704\,h_2 + 19.2974\,h_3 \\
& - 13.3971\,p_1 - 15.4639\,p_2 + 2.4144\,p_3
\end{aligned}
$$

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$$194''.94 = -11.7320\,\delta n + 3.6520\,\delta y_1 + 15.0680\,\delta y_2 + 0.1951\,k_1 + 7.3294\,k_2 + 14.7069\,k_3 - 0.5785\,q_1 - 0.5496\,q_2 + 2.3663\,q_3$$

38. By means of (ε) and (n) of Articles 35 and 36, eliminate $\delta\varepsilon$ and δn from (x) and (y), and also from the equations just found, and we have

$$(x)\quad 202''.72 = 6.5294\,\delta x_1 + 5.4577\,\delta x_2 + 3.3234\,h_1 + 8.0291\,h_2 + 6.4240\,h_3 + 1.2659\,p_1 + 0.6477\,p_2 + 5.6529\,p_3$$

$$(y)\quad 42.61 = 1.2578\,\delta y_1 + 3.3771\,\delta y_2 + 0.3822\,k_1 + 2.0739\,k_2 + 3.3916\,k_3 + 0.0836\,q_1 + 0.0298\,q_2 + 0.9513\,q_3$$

$$268.02 = 11.1297\,\delta x_1 + 14.4919\,\delta x_2 + 5.3967\,h_1 + 14.4642\,h_2 + 15.4449\,h_3 + 2.0175\,p_1 + 1.0266\,p_2 + 9.4702\,p_3$$

$$168.85 = 5.0833\,\delta y_1 + 14.8824\,\delta y_2 + 1.5261\,k_1 + 8.4906\,k_2 + 14.6979\,k_3 + 0.3320\,q_1 + 0.1189\,q_2 + 3.8313\,q_3$$

39. Substituting for δx_2, δy_2, their values in terms of δx_1, δy_1, we find

$$6.5294\,\delta x_1 + 5.4577\,\delta x_2 = 6.5700\,\delta x_1 + 0.0490\,\delta y_1$$
$$1.2578\,\delta y_1 + 3.3771\,\delta y_2 = -0.0303\,\delta x_1 + 1.2829\,\delta y_1$$
$$11.1297\,\delta x_1 + 14.4919\,\delta x_2 = 11.2378\,\delta x_1 + 0.1300\,\delta y_1$$
$$5.0833\,\delta y_1 + 14.8824\,\delta y_2 = -0.1335\,\delta x_1 + 5.1943\,\delta y_1$$

Hence, if we add to the two latter equations

$$-1.7106\ (x) - 0.03607\ (y)$$

and

$$0.00165\ (x) - 4.0487\ (y) \text{ respectively,}$$

δx_1 and δy_1 will be eliminated, and we shall obtain the following equations:—

$$(1)\quad 80''.28 = 0.2883\,h_1 - 0.7295\,h_2 - 4.4559\,h_3 + 0.0138\,k_1 + 0.0748\,k_2 + 0.1223\,k_3 + 0.1479\,p_1 + 0.0813\,p_2 + 0.1997\,p_3 + 0.0030\,q_1 + 0.0011\,q_2 + 0.0343\,q_3$$

$$(2)\quad 3.34 = -0.0055\,h_1 - 0.0132\,h_2 - 0.0106\,h_3 + 0.0212\,k_1 - 0.0939\,k_2 - 0.9662\,k_3 - 0.0021\,p_1 - 0.0011\,p_2 - 0.0093\,p_3 + 0.0066\,q_1 + 0.0017\,q_2 + 0.0203\,q_3$$

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40. Again, the equations of condition given by the ancient observations are

$$
\begin{aligned}
62''.6 = {} & \delta\epsilon - 0.8776\,\delta x_1 + 0.5402\,\delta x_2 + 0.7923\,h_1 + 0.2554\,h_2 \\
-39.31\,{} & \delta n - 0.4795\,\delta y_1 + 0.8415\,\delta y_2 + 0.6101\,k_1 + 0.9668\,k_2 \\
& - 0.3875\;h_3 - 0.9877\;p_1 - 0.6870\,p_2 - 0.1009\,p_3 \\
& + 0.9219\;k_3 + 0.1566\;q_1 - 0.7267\,q_2 - 0.9949\,q_3
\end{aligned}
$$

$$
\begin{aligned}
84.5 = {} & \delta\epsilon + 0.4975\,\delta x_1 - 0.5050\,\delta x_2 - 0.0887\,h_1 - 0.9843\,h_2 \\
-32.30\,{} & \delta n - 0.8675\,\delta y_1 - 0.8631\,\delta y_2 + 0.9961\,k_1 - 0.1767\,k_2 \\
& + 0.2634\;h_3 - 0.9085\;p_1 - 0.3355\,p_2 + 0.9681\,p_3 \\
& - 0.9647\;k_3 - 0.4178\;q_1 - 0.9420\,q_2 - 0.2506\,q_3
\end{aligned}
$$

$$
\begin{aligned}
67.2 = {} & \delta\epsilon + 0.6732\,\delta x_1 - 0.0935\,\delta x_2 - 0.2243\,h_1 - 0.8994\,h_2 \\
-31.34\,{} & \delta n - 0.7394\,\delta y_1 - 0.9956\,\delta y_2 + 0.9745\,k_1 - 0.4371\,k_2 \\
& + 0.6277\;h_3 - 0.8720\;p_1 - 0.2815\,p_2 + 0.9982\,p_3 \\
& - 0.7785\;k_3 - 0.4895\;q_1 - 0.9596\,q_2 - 0.0591\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-51.8 = {} & \delta\epsilon - 0.2616\,\delta x_1 - 0.8631\,\delta x_2 - 0.9436\,h_1 + 0.7809\,h_2 \\
-19.59\,{} & \delta n + 0.9652\,\delta y_1 - 0.5050\,\delta y_2 - 0.3310\,k_1 + 0.6247\,k_2 \\
& - 0.5301\;h_3 - 0.0731\;p_1 + 0.3991\,p_2 - 0.6801\,p_3 \\
& - 0.8479\;k_3 - 0.9973\;q_1 - 0.9169\,q_2 + 0.7331\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-43.2 = {} & \delta\epsilon - 0.4741\,\delta x_1 - 0.5505\,\delta x_2 - 0.8861\,h_1 + 0.5704\,h_2 \\
-18.58\,{} & \delta n + 0.8805\,\delta y_1 - 0.8348\,\delta y_2 - 0.4634\,k_1 + 0.8213\,k_2 \\
& - 0.1248\;h_3 + 0.0115\;p_1 + 0.4532\,p_2 - 0.8147\,p_3 \\
& - 0.9922\;k_3 - 0.9999\;q_1 - 0.8914\,q_2 + 0.5798\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-50.1 = {} & \delta\epsilon - 0.6430\,\delta x_1 - 0.1731\,\delta x_2 - 0.8191\,h_1 + 0.3420\,h_2 \\
-17.68\,{} & \delta n + 0.7659\,\delta y_1 - 0.9849\,\delta y_2 - 0.5736\,k_1 + 0.9397\,k_2 \\
& + 0.2588\;h_3 + 0.0871\;p_1 + 0.5001\,p_2 - 0.9063\,p_3 \\
& - 0.9659\;k_3 - 0.9962\;q_1 - 0.8660\,q_2 + 0.4225\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-37.8 = {} & \delta\epsilon - 0.9492\,\delta x_1 + 0.8021\,\delta x_2 - 0.5743\,h_1 - 0.3404\,h_2 \\
-15.25\,{} & \delta n + 0.3145\,\delta y_1 - 0.5972\,\delta y_2 - 0.8186\,k_1 + 0.9403\,k_2 \\
& + 0.9652\;h_3 + 0.2872\;p_1 + 0.6192\,p_2 - 0.9984\,p_3 \\
& - 0.2613\;k_3 - 0.9579\;q_1 - 0.7852\,q_2 - 0.0560\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-20.5 = {} & \delta\epsilon - 0.9985\,\delta x_1 + 0.9942\,\delta x_2 - 0.3671\,h_1 - 0.7304\,h_2 \\
-13.60\,{} & \delta n - 0.0538\,\delta y_1 + 0.1074\,\delta y_2 - 0.9302\,k_1 + 0.6830\,k_2 \\
& + 0.9035\;h_3 + 0.4164\;p_1 + 0.6928\,p_2 - 0.9251\,p_3 \\
& + 0.4286\;k_3 - 0.9092\;q_1 - 0.7212\,q_2 - 0.3796\,q_3
\end{aligned}
$$

$$
\begin{aligned}
-\ 2.4 = {} & \delta\epsilon - 0.9633\,\delta x_1 + 0.8560\,\delta x_2 - 0.2363\,h_1 - 0.8883\,h_2 \\
-12.64\,{} & \delta n - 0.2684\,\delta y_1 + 0.5170\,\delta y_2 - 0.9717\,k_1 + 0.4593\,k_2 \\
& + 0.6562\;h_3 + 0.4882\;p_1 + 0.7327\,p_2 - 0.8345\,p_3 \\
& - 0.7546\;k_3 - 0.8727\;q_1 - 0.6806\,q_2 - 0.5511\,q_3
\end{aligned}
$$

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41. The equation for finding p_3 may be formed as before, by multiplying the above equations taken in order by

$$-0{\cdot}8,\ -0{\cdot}6,\ +1{\cdot}0,\ +1{\cdot}0,\ +0{\cdot}9,\ +0{\cdot}6,\ +0{\cdot}4,\ +0{\cdot}3,$$

beginning with the second; and the equation for q_3 by multiplying the same equations by

$$1{\cdot}0,\ 1{\cdot}0,\ 0{\cdot}5,\ 0{\cdot}4,\ 0{\cdot}3,\ 0{\cdot}2,\ 0{\cdot}1,\ 0{\cdot}1.$$

Thus we obtain

$$\begin{aligned}
-279''{\cdot}64 = \quad & 2{\cdot}80\ \delta\varepsilon - 3{\cdot}3742\ \delta x_1 + 0{\cdot}0265\ \delta x_2 - 2{\cdot}9237\ h_1 + 2{\cdot}2232\ h_2 \\
& -27{\cdot}82\ \delta n + 3{\cdot}7593\ \delta y_1 - 1{\cdot}0986\ \delta y_2 - 3{\cdot}8471\ k_1 + 3{\cdot}6706\ k_2 \\
& + 0{\cdot}1281\ h_3 + 1{\cdot}7522\ p_1 + 2{\cdot}6081\ p_2 - 4{\cdot}9033\ p_3 \\
& - 1{\cdot}2295\ k_3 - 3{\cdot}4661\ q_1 - 2{\cdot}2221\ q_2 + 1{\cdot}5785\ q_3 \\
83{\cdot}56 = \quad & 3{\cdot}60\ \delta\varepsilon + 0{\cdot}2714\ \delta x_1 - 0{\cdot}9567\ \delta x_2 - 1{\cdot}5602\ h_1 - 1{\cdot}3924\ h_2 \\
& -91{\cdot}84\ \delta n - 0{\cdot}5116\ \delta y_1 - 2{\cdot}7976\ \delta y_2 + 1{\cdot}0937\ k_1 + 0{\cdot}6112\ k_2 \\
& + 1{\cdot}0027\ h_3 - 1{\cdot}6385\ p_1 + 0{\cdot}1802\ p_2 + 0{\cdot}6529\ p_3 \\
& - 2{\cdot}7879\ k_3 - 2{\cdot}4746\ q_1 - 3{\cdot}2736\ q_2 + 0{\cdot}3113\ q_3
\end{aligned}$$

42. Eliminate $\delta\varepsilon$ and δn by means of (ε) and (n) of Articles 35 and 36, and these equations become

$$\begin{aligned}
-361''{\cdot}72 = \quad & -\ 4{\cdot}1831\ \delta x_1 + 0{\cdot}6179\ \delta x_2 -\ 4{\cdot}7839\ h_1 +\ 2{\cdot}0969\ h_2 \\
& +\ 7{\cdot}1533\ \delta y_1 - 1{\cdot}5388\ \delta y_2 -\ 0{\cdot}6909\ k_1 +\ 6{\cdot}4242\ k_2 \\
& +\ 0{\cdot}7410\ h_3 - 0{\cdot}7000\ p_1 -\ 0{\cdot}0153\ p_2 -\ 6{\cdot}0258\ p_3 \\
& -\ 1{\cdot}2508\ k_3 - 1{\cdot}3068\ q_1 -\ 0{\cdot}6369\ q_2 +\ 5{\cdot}0525\ q_3 \\
-146{\cdot}69 = \quad & -\ 0{\cdot}7686\ \delta x_1 - 0{\cdot}1963\ \delta x_2 -\ 3{\cdot}9519\ h_1 -\ 1{\cdot}5548\ h_2 \\
& +10{\cdot}6926\ \delta y_1 - 4{\cdot}2508\ \delta y_2 + 11{\cdot}5128\ k_1 +\ 9{\cdot}7013\ k_2 \\
& +\ 1{\cdot}7907\ h_3 - 4{\cdot}7913\ p_1 -\ 3{\cdot}1927\ p_2 -\ 0{\cdot}7902\ p_3 \\
& -\ 2{\cdot}8583\ k_3 + 4{\cdot}6536\ q_1 +\ 1{\cdot}9595\ q_2 + 11{\cdot}7796\ q_3
\end{aligned}$$

43. Substituting for δx_2, δy_2, their values in terms of δx_1, δy_1, we find

$$\begin{aligned}
-4{\cdot}1831\ \delta x_1 + 7{\cdot}1533\ \delta y_1 + 0{\cdot}6179\ \delta x_2 - 1{\cdot}5388\ \delta y_2 &= -4{\cdot}1647\ \delta x_1 + 7{\cdot}1473\ \delta y_1 \\
-0{\cdot}7686\ \delta x_1 + 10{\cdot}6926\ \delta y_1 - 0{\cdot}1963\ \delta x_2 - 4{\cdot}2508\ \delta y_2 &= -0{\cdot}7319\ \delta x_1 + 10{\cdot}6591\ \delta y_1
\end{aligned}$$

Hence, if to the equations just found we add

$$+0{\cdot}60808\ (x) - 5{\cdot}5942\ (y)$$

and

$$+0{\cdot}07306\ (x) - 8{\cdot}3110\ (y)\ \text{respectively,}$$

δx_1 and δy_1 will be eliminated, and we shall obtain the following equations:—

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$$(3)\quad -476''.84 = -2.7630\,h_1+6.9793\,h_2-4.6473\,h_3 \\ -2.8290\,k_1-5.1777\,k_2-20.2242\,k_3 \\ +0.0698\,p_1+0.3785\,p_2-2.5884\,p_3 \\ -1.7748\,q_1-0.8036\,q_2-0.2693\,q_3$$

$$(4)\quad -486.03 = -3.7091\,h_1-0.9682\,h_2+2.2600\,h_3 \\ +8.3364\,k_1-7.5348\,k_2-31.0457\,k_3 \\ -4.6988\,p_1-3.1454\,p_2-0.3772\,p_3 \\ +3.9584\,q_1+1.7118\,q_2+3.8734\,q_3$$

44. Eliminate the left-hand members from equations (2), (3), and (4), of Articles 39 and 43, by means of equation (1), and we have

$$0 = 0.4200\,h_1-0.4114\,h_2-4.2014\,h_3+0.1980\,p_1+0.1069\,p_2+0.4236\,p_3 \\ -0.4964\,k_1+2.3306\,k_2+23.3213\,k_3-0.1567\,q_1-0.0409\,q_2-0.4531\,q_3$$

$$0 = -1.0507\,h_1+2.6465\,h_2-21.8182\,h_3+0.9482\,p_1+0.8614\,p_2-1.4023\,p_3 \\ -2.7471\,k_1-4.7334\,k_2-19.4976\,k_3-1.7569\,q_1-0.7972\,q_2-0.0655\,q_3$$

$$0 = -1.9638\,h_1-5.3845\,h_2-24.7155\,h_3-3.8034\,p_1-2.6532\,p_2+0.8317\,p_3 \\ +8.4199\,k_1-7.0819\,k_2-30.3051\,k_3+3.9767\,q_1+1.7183\,q_2+4.0811\,q_3$$

45. If, as before, we put $\varepsilon-\varepsilon' = \theta$, and $\varepsilon-\varpi = \beta$, it may be seen that

$$\frac{h_1}{m'} = -42''.33\sin\theta \qquad \frac{h_2}{m'} = 76''.55\sin 2\theta$$

$$\frac{k_1}{m'} = -42.33\cos\theta \qquad \frac{k_2}{m'} = 76.55\cos 2\theta$$

$$\frac{h_3}{m'} = 7.25\sin 3\theta+0.007460\frac{p_3}{m'}+0.008974\frac{q_3}{m'}$$

$$\frac{k_3}{m'} = 7.25\cos 3\theta-0.008974\frac{p_3}{m'}+0.007460\frac{q_3}{m'}$$

$$\frac{p_1}{m'} = 0.20\sin(\theta-\beta)-0.074738\left\{\frac{p_3}{m'}\cos 2\theta-\frac{q_3}{m'}\sin 2\theta\right\}$$

$$\frac{q_1}{m'} = -0.20\cos(\theta-\beta)+0.074738\left\{\frac{p_3}{m'}\sin 2\theta+\frac{q_3}{m'}\cos 2\theta\right\}$$

$$\frac{p_2}{m'} = 32.91\sin(2\theta-\beta)+0.259765\left\{\frac{p_3}{m'}\cos\theta-\frac{q_3}{m'}\sin\theta\right\}$$

$$\frac{q_2}{m'} = 32.91\cos(2\theta-\beta)+0.259765\left\{\frac{p_3}{m'}\sin\theta+\frac{q_3}{m'}\cos\theta\right\}$$

46. Substituting these expressions in the above equations, and putting for β its value, 50° 15′.8, we obtain

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$$0 = -(1\cdot24872)\sin\theta+(1\cdot32231)\cos\theta-(1\cdot48110)\sin 2\theta+(2\cdot24265)\cos 2\theta$$
$$-(1\cdot48373)\sin 3\theta+(2\cdot22809)\cos 3\theta+(9\cdot26254)\frac{p_3}{m'}-(9\cdot50079)\frac{q_3}{m'}$$
$$+(8\cdot44376)\left\{\frac{p_3}{m'}\cos\theta-\frac{q_3}{m'}\sin\theta\right\}-(8\cdot02630)\left\{\frac{p_3}{m'}\sin\theta+\frac{q_3}{m'}\cos\theta\right\}$$
$$-(8\cdot17031)\left\{\frac{p_3}{m'}\cos 2\theta-\frac{q_3}{m'}\sin 2\theta\right\}-(8\cdot06861)\left\{\frac{p_3}{m'}\sin 2\theta+\frac{q_3}{m'}\cos 2\theta\right\}$$

$$0 = (1\cdot65190)\sin\theta+(2\cdot06584)\cos\theta+(2\cdot30220)\sin 2\theta-(2\cdot60306)\cos 2\theta$$
$$-(2\cdot19916)\sin 3\theta-(2\cdot15032)\cos 3\theta-(0\cdot14305)\frac{p_3}{m'}-(9\cdot60933)\frac{q_3}{m'}$$
$$+(9\cdot34981)\left\{\frac{p_3}{m'}\cos\theta-\frac{q_3}{m'}\sin\theta\right\}-(9\cdot31615)\left\{\frac{p_3}{m'}\sin\theta+\frac{q_3}{m'}\cos\theta\right\}$$
$$-(8\cdot85046)\left\{\frac{p_3}{m'}\cos 2\theta-\frac{q_3}{m'}\sin 2\theta\right\}-(9\cdot11828)\left\{\frac{p_3}{m'}\sin 2\theta+\frac{q_3}{m'}\cos 2\theta\right\}$$

$$0 = (1\cdot91407)\sin\theta-(2\cdot55189)\cos\theta-(2\cdot62790)\sin 2\theta-(2\cdot64230)\cos 2\theta$$
$$-(2\cdot25331)\sin 3\theta-(2\cdot34185)\cos 3\theta+(9\cdot96344)\frac{p_3}{m'}+(0\cdot56029)\frac{q_3}{m'}$$
$$-(9\cdot83835)\left\{\frac{p_3}{m'}\cos\theta-\frac{q_3}{m'}\sin\theta\right\}+(9\cdot64968)\left\{\frac{p_3}{m'}\sin\theta+\frac{q_3}{m'}\cos\theta\right\}$$
$$+(9\cdot45371)\left\{\frac{p_3}{m'}\cos 2\theta-\frac{q_3}{m'}\sin 2\theta\right\}+(9\cdot47306)\left\{\frac{p_3}{m'}\sin 2\theta+\frac{q_3}{m'}\cos 2\theta\right\}$$

where the numbers enclosed within parentheses denote the logarithms of the corresponding coefficients, as before.

47. From these equations we find, by the same method as before,

$$\theta = -46^\circ\ 55' \qquad \frac{p_3}{m'} = 138''\cdot92 \qquad \frac{q_3}{m'} = -109''\cdot83$$

Hence, since $\varepsilon = 217^\circ\ 55'$, $\varepsilon' = 264^\circ\ 50'$, the mean longitude of the disturbing planet at the epoch 1810·328. The sidereal motion in 36 synodic periods of *Uranus* $= 57^\circ\ 42'$, precession $= 30'$. $\therefore$ mean longitude at the time 1846·762, or October 6, 1846, $= 323^\circ\ 2'$.

Also, the expressions for $\frac{p_3}{m'}$ and $\frac{q_3}{m'}$ are

$$\frac{p_3}{m'} = 33''\cdot93\sin(3\theta-\beta)-63''\cdot41\,e'\sin(3\theta-\beta')$$
$$\frac{q_3}{m'} = 33\cdot93\cos(3\theta-\beta)-63\cdot41\,e'\cos(3\theta-\beta')$$

where $\varepsilon-\varpi' = \beta'$.

Equating these to the values given above, we find $e' = 2\cdot4123$, $\beta' = 279^\circ\ 14'$, and $\therefore\ \varpi' = 298^\circ\ 41'$. Hence longitude of the perihelion in 1846 $= 299^\circ\ 11'$.

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Lastly, substituting the values just obtained in equation (1) of Article 39, we find $m' = 0{\cdot}75017$.

48. Hence the values of the mass and elements of the orbit of the disturbing planet, resulting from the second hypothesis as to the mean distance, are the following :—

$$\frac{a}{a'} = 0{\cdot}515$$

Mean longitude of the Planet, October 6, 1846 ..	323° 2′
Longitude of the Perihelion	299 11
Eccentricity of the Orbit	0·120615
Mass (that of the Sun being 1)	0·00015003

49. From the values of m', θ, $\frac{p_3}{m'}$, and $\frac{q_3}{m'}$, found above, the values of the quantities h, k, p, and q, corresponding to each hypothesis, are immediately determined. Thus we find,

1st Hypothesis.

$$\frac{a}{a'} = 0{\cdot}5$$

$h_1 =$	23″·98	$k_1 =$	− 19″·07
$h_2 =$	− 47·58	$k_2 =$	− 11·00
$h_3 =$	− 1·93	$k_3 =$	− 7·64
$p_1 =$	9·93	$q_1 =$	− 8·31
$p_2 =$	− 8·54	$q_2 =$	− 55·36
$p_3 =$	224·90	$q_3 =$	−171·63

2d Hypothesis.

$$\frac{a}{a'} = 0{\cdot}515$$

$h_1 =$	23″·19	$k_1 =$	−21″·69
$h_2 =$	− 57·30	$k_2 =$	− 3·83
$h_3 =$	− 3·40	$k_3 =$	− 5·76
$p_1 =$	6·52	$q_1 =$	− 7·34
$p_2 =$	− 11·62	$q_2 =$	−54·39
$p_3 =$	104·21	$q_3 =$	−82·39

50. And by substituting these values in the equations (ε), (n), (x), and (y), we obtain

1st Hypothesis.

$$\frac{a}{a'} = 0{\cdot}5$$

$\delta\iota =$	− 49″·77	$\delta n =$	−0″·702
$\delta x_1 =$	−130·69	$\delta y_1 =$	222·38
$\delta x_2 =$	1·02	$\delta y_2 =$	2·83

2d Hypothesis.

$$\frac{a}{a'} = 0{\cdot}515$$

$\delta\iota =$	−43″·23	$\delta n =$	− 0″·5417
$\delta x_1 =$	1·77	$\delta y_1 =$	123·98
$\delta x_2 =$	1·13	$\delta y_2 =$	0·91

and the corresponding corrections of the elliptic elements will be

$$\frac{\delta a}{a} = 0{\cdot}00000999$$

$$\delta e = 20″{\cdot}83$$
$$e\delta\varpi = 127{\cdot}27$$

$$\frac{\delta a}{a} = 0{\cdot}00000771$$

$$\delta e = 40″{\cdot}31$$
$$e\delta\varpi = 47{\cdot}10$$

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It will be seen that the corrections of the eccentricity and longitude of perihelion vary very rapidly with a change in the assumed mean distance.

51. If these quantities be substituted in the expressions before given, we obtain the following theoretical corrections of the mean longitude, each of these corrections being divided into two parts, of which the first is due to the changes in the elements of the orbit of *Uranus*, and the second to the action of the disturbing planet.

Hypothesis I.

Ancient Observations.

Year.				
1712	−288″·0	+365″·8	=	+77″·8
1715	−283·1	+357·1	=	+74·0
1750	+210·5	−260·7	=	−50·2
1753	+218·1	−267·0	=	−48·9
1756	+214·0	−260·0	=	−46·0
1764	+154·0	−186·7	=	−32·7
1769	+ 79·6	−100·7	=	−21·1
1771	+ 27·6	− 41·8	=	−14·2

Modern Observations.

Year.				
1780	−126″·12	+129″·27	=	+ 3″·15
1783	−180·28	+188·70	=	+ 8·42
1786	−227·66	+240·36	=	+12·70
1789	−265·70	+281·63	=	+15·93
1792	−292·25	+310·38	=	+18·13
1795	−305·84	+325·27	=	+19·43
1798	−305·67	+325·72	=	+20·05
1801	−291·77	+312·05	=	+20·28
1804	−264·95	+285·38	=	+20·43
1807	−226·78	+247·51	=	+20·73
1810	−179·43	+200·76	=	+21·33
1813	−125″·59	+147″·72	=	+22″·13
1816	− 68·21	+ 91·02	=	+22·81
1819	− 10·40	+ 33·18	=	+22·78
1822	+ 44·84	− 23·64	=	+21·20
1825	+ 94·69	− 77·64	=	+17·05
1828	+136·73	−127·48	=	+ 9·25
1831	+168·94	−172·17	=	− 3·23
1834	+189·85	−211·04	=	−21·19
1837	+198·51	−243·59	=	−45·08
1840	+194·54	−269·36	=	−74·82

Hypothesis II.

Ancient Observations.

Year.				
1712	−133″·7	+211″·9	=	+78″·2
1715	−117·7	+191·5	=	+73·8
1750	+ 85·2	−134·4	=	−49·2
1753	+ 73·8	−122·2	=	−48·4
1756	+ 59·1	−105·2	=	−46·1
1764	+ 2·7	− 36·4	=	−33·7
1769	− 43·1	+ 20·8	=	−22·3
1771	− 69·9	+ 54·7	=	−15·2

Modern Observations.

Year.				
1780	−133″·10	+135″·98	=	+ 2″·88
1783	−149·47	+157·87	=	+ 8·40
1786	−160·15	+172·99	=	+12·84
1789	−164·52	+180·64	=	+16·12
1792	−162·30	+180·58	=	+18·28
1795	−153·59	+173·07	=	+19·48
1798	−138·87	+158·86	=	+19·99
1801	−118·95	+139·08	=	+20·13
1804	− 94·96	+115·21	=	+20·25
1807	− 68·25	+ 88·85	=	+20·60
1810	− 40·33	+ 61·61	=	+21·28
1813	−12″·72	+ 34″·91	=	+22″·19
1816	+13·08	+ 9·88	=	+22·96
1819	+35·71	− 12·74	=	+22·97
1822	+54·04	− 32·68	=	+21·36
1825	+67·18	− 50·08	=	+17·10
1828	+74·52	− 65·37	=	+ 9·15
1831	+75·74	− 79·21	=	− 3·47
1834	+70·85	− 92·31	=	−21·46
1837	+60·08	−105·25	=	−45·17
1840	+43·98	−118·38	=	−74·40

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52. Comparing these with the corrections of mean longitude derived from observation, we find the remaining differences to be the following:—

Ancient Observations.

Year.	Observation—Theory. Hypoth. I.	Hypoth. II.
1712	+ 6″7	+ 6″3
1715	− 6·8	− 6·6
1750	− 1·6	− 2·6
1753	+ 5·7	+ 5·2
1756	− 4·1	− 4·0
1764	− 5·1	− 4·1
1769	+ 0·6	+ 1·8
1771	+11·8	+12·8

Modern Observations.

Year.	Observation—Theory. Hypoth. I.	Hypoth. II.
1780	+0″·27	+0″·54
1783	−0·23	−0·21
1786	−0·96	−1·10
1789	+1·82	+1·63
1792	−0·91	−1·06
1795	+0·09	+0·04
1798	−0·99	−0·93
1801	−0·04	+0·11
1804	+1·76	+1·94
1807	−0·21	−0·08
1810	+0·56	+0·61
1813	−0″·94	−1″·00
1816	−0·31	−0·46
1819	−2·00	−2·19
1822	+0·30	+0·14
1825	+1·92	+1·87
1828	+2·25	+2·35
1831	−1·06	−0·82
1834	−1·44	−1·17
1837	−1·62	−1·53
1840	+1·73	+1·31

The largest difference in the above table, viz. that for 1771, is deduced from a single observation; whereas the difference immediately preceding it, which is deduced from the mean of several, is very small.

53. The results of the two theories agree very closely with each other, and with observation, till we come to the later years of the series; and it is to be observed, that the difference between the theories becomes sensible at precisely the point where they both shew symptoms of diverging from the observations, the errors of the second hypothesis, however, being less than those of the other.

Recent observations shew that the errors of the theory soon become very sensible, though decidedly less for the second hypothesis than for the first. The following are the differences of mean longitude, as deduced from theory and observation, for the oppositions of 1843, 1844, and 1845:—

Year.	Observation—Theory. Hypoth. I.	Hypoth. II.
1843	+ 7″·11	+ 5″·77
1844	+ 8·79	+ 7·05
1845	+12·40	+10·18

For the observations of the last two years, I am indebted to the kindness

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of the Astronomer Royal. The three years nearly agree in shewing that the errors of the first hypothesis are to those of the second in the ratio of 5 to 4, from which I inferred, in a letter to the Astronomer Royal, dated September 2, 1846, that the assumption of $\frac{a}{a'} = \sin 35^\circ = 0{\cdot}574$, would probably satisfy all the observations very nearly.

54. The results which I have deduced from Professor Challis's observations of the planet, strongly confirm the inference that the mean distance should be considerably diminished. It is of course impossible to determine precisely, without actual calculation, the alteration in longitude which would be produced by such a diminution in the distance. By comparing the values of θ given by the two hypotheses, it may be seen, however, that if we took successively smaller and smaller values for the mean distance, the values found for the mean longitude in 1810 would probably go on diminishing, while at the same time the mean motion from 1810 to 1846 would rapidly increase, so that the corresponding values of the mean longitude at the present time would probably soon arrive at a minimum, and afterwards begin again to increase. This I believe to be the reason why the longitude found on the supposition of too large a value for the mean distance agrees so nearly with observation. In consequence of not making sufficient allowance for the increase in the mean motion, I hastily inferred, in my letter to the Astronomer Royal mentioned above, that the effect of a diminution in the mean distance would be to diminish the mean longitude.

55. I have already mentioned, that I thought it unsafe to employ Flamsteed's observations of 1690 in forming the equations of condition, as the interval between it and all the others is so large. The difference between it and the theory appears to be very considerable, and greater for the second hypothesis than for the first, the errors being $+44''{\cdot}5$ and $+50''{\cdot}0$ respectively. These errors would probably be increased by diminishing the mean distance. It would be desirable that Flamsteed's manuscripts should be examined with reference to this point.

56. The corrections of the tabular radius vector of *Uranus* may be easily deduced from those of the mean longitude by means of the following formula :—

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$$\frac{\delta r}{r} = \frac{1}{r}\frac{dr}{d\varepsilon}\delta\zeta - \frac{1}{2n}\frac{d}{dt}\delta\zeta + \frac{1}{4}\frac{\delta a}{a} - \frac{1}{2}\frac{e\delta e}{1-e^2} - \frac{1}{6}m'a^2\frac{dA_0}{da}$$
$$+\frac{m'}{2}\Sigma C_i \cos i\{nt-n't+\varepsilon-\varepsilon'\}$$
$$+m'e\,\Sigma D_i \cos\{i(nt-n't+\varepsilon-\varepsilon')-nt-\varepsilon+\varpi\}$$
$$+m'e'\,\Sigma E_i \cos\{i(nt-n't+\varepsilon-\varepsilon')-nt-\varepsilon+\varpi'\}$$

where $\delta\zeta$ denotes the whole correction of the mean longitude at the time t,

$$\frac{1}{r}\frac{dr}{d\varepsilon} = e\sin\{nt+\varepsilon-\varpi\} + \frac{3}{2}e^2\sin 2\{nt+\varepsilon-\varpi\} \text{ nearly,}$$

$$C_i = \frac{1}{2}\frac{n}{n-n'}aA^i$$

$$D_i = -\frac{1}{4}\frac{in}{i(n-n')-n}\left\{2iaA_i + a^2\frac{dA_i}{da}\right\}$$

$$E_i = \frac{1}{4}\frac{(i-1)n}{i(n-n')-n}\left\{(2i-1)aA_{i-1} + a^2\frac{dA_{i-1}}{da}\right\}$$

i assuming all integral values positive and negative not including zero.

57. By substituting in this formula the values m', δa, δe, &c., already obtained, and putting $a = 19{\cdot}191$, we find the following results corresponding to the two assumed values of the mean distance.

Hypothesis I.

$$\frac{a}{r}\delta r = \frac{a}{r}\frac{dr}{d\varepsilon}\delta\zeta - \frac{a}{2}\frac{d\delta\zeta}{ndt} - 0{\cdot}000089$$
$$+0{\cdot}000069\cos\{nt-n't+\varepsilon-\varepsilon'\}$$
$$+0{\cdot}000259\cos 2\{nt-n't+\varepsilon-\varepsilon'\}$$
$$+0{\cdot}000109\cos 3\{nt-n't+\varepsilon-\varepsilon'\}$$
$$+0{\cdot}000016\cos\{n't+\varepsilon'-\varpi\}$$
$$-0{\cdot}000168\cos\{nt-2n't+\varepsilon-2\varepsilon'+\varpi\}$$
$$+0{\cdot}000078\cos\{nt-2n't+\varepsilon-2\varepsilon'+\varpi'\}$$
$$-0{\cdot}000049\cos\{2nt-3n't+2\varepsilon-3\varepsilon'+\varpi\}$$
$$+0{\cdot}000209\cos\{2nt-3n't+2\varepsilon-3\varepsilon'+\varpi'\}$$

Hypothesis II.

$$\frac{a}{r}\delta r = \frac{a}{r}\frac{dr}{d\varepsilon}\delta\zeta - \frac{a}{2}\frac{d\delta\zeta}{ndt} - 0{\cdot}000144$$
$$+0{\cdot}000073\cos\{nt-n't+\varepsilon-\varepsilon'\}$$
$$+0{\cdot}000266\cos 2\{nt-n't+\varepsilon-\varepsilon'\}$$
$$+0{\cdot}000115\cos 3\{nt-n't+\varepsilon-\varepsilon'\}$$

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$$+0\cdot000016\cos\{n't+\epsilon'-\varpi\}$$
$$-0\cdot000188\cos\{nt-2n't+\epsilon-2\epsilon'+\varpi\}$$
$$+0\cdot000068\cos\{nt-2n't+\epsilon-2\epsilon'+\varpi'\}$$
$$-0\cdot000053\cos\{2nt-3n't+2\epsilon-3\epsilon'+\varpi\}$$
$$+0\cdot000165\cos\{2nt-3n't+2\epsilon-3\epsilon'+\varpi'\}$$

58. The values of $\delta\zeta$ and $\frac{d\delta\zeta}{dt}$ for several late years are the following :—

Hypothesis I.

Year.	$\delta\zeta$	$\frac{d\delta\zeta}{dt}$
1834	$-21''\cdot19$	$-20''\cdot93$
1840	$-74\cdot82$	$-32\cdot34$
1846	$-148\cdot65$	$-39\cdot94$

Hypothesis II.

1834	$-21''\cdot46$	$-20''\cdot85$
1840	$-74\cdot40$	$-31\cdot62$
1846	$-145\cdot91$	$-38\cdot30$

Hence, by means of the above formulæ, we find the corrections of the tabular radius vector to be

Year.	Hypothesis I.	Hypothesis II.
1834	+0·00505	+0·00492
1840	+0·00722	+0·00696
1846	+0·00868	+0·00825

59. By far the most important part of these corrections arises from the term $-\frac{1}{2}r\frac{d\delta\zeta}{ndt}$, and may therefore be immediately deduced from a comparison of the observed angular motion of *Uranus* with that given by the tables. In fact, the corrections given by this term alone for the epochs above mentioned are,

Year.	Hypothesis I.	Hypothesis II.
1834	+0·00447	+0·00445
1840	+0·00694	+0·00678
1846	+0·00853	+0·00818

which, as we see, differ very little from the complete values just found. The correction for 1834 very nearly agrees with that which Mr. Airy has deduced from observation in the *Astronomische Nachrichten*. The corrections for

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subsequent years are rather larger than those given by the Greenwich Observations, the results of the second hypothesis being, as in the case of the longitude, nearer the truth than those of the first.

60. I made some attempts, by discussing the observations of latitude, to find approximate values of the longitude of the node and inclination of the orbit of the disturbing planet, but the results were not satisfactory. The perturbations of the latitude are, in fact, exceedingly small, and during the comparatively short period of three-fourths of a revolution are nearly confounded with the effects of a constant alteration in the inclination and the position of the node of *Uranus*, so that very small errors in the observations may entirely vitiate the result.

61. The perturbations of *Saturn* produced by the new planet, though small, will still be sensible, and it would be interesting to inquire whether, if they were taken into account, the values of the masses of *Jupiter* and *Uranus* found from their action on *Saturn* would be more consistent with those determined by other means than they appear to be at present. The reduction of the Greenwich planetary observations renders such an inquiry comparatively easy, and it is to be hoped that English astronomers will not be the last to avail themselves of the treasures of observation thus laid open to the world.

J. C. ADAMS.

St. John's College, Cambridge,
November 12, 1846.

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XVII. *Elements of the Binary Star γ Virginis.* *By J. R. Hind, Esq.*

Read June 11, 1847.

The following orbit for this interesting double star has been computed agreeably to the method described by Encke, in the *Berliner Jahrbuch* for 1832. It is a curious circumstance, and one which deserves attention, that none of the orbits at present calculated for *γ Virginis* represent the state of singleness at the end of 1835 and beginning of 1836, so fortunately viewed by Sir John Herschel at the Cape of Good Hope, and by Captain Smyth at Bedford. Before employing Encke's method, I made numerous attempts to explain this apparent anomaly by graphical projection of the orbit, but could arrive at no results at all satisfactory. The orbit here communicated is equally at fault as far as regards the singleness of the star, but with this exception, the series of observations (both of position and distance) is represented with tolerable accuracy.

From the alignments of Bradley and Pound, Sir John Herschel obtained an angle = 160° 52′, in 1718. (*Mem. Astron. Soc.* vol. v. p. 36.) In the appendix to vol. i. of Captain Smyth's *Cycle*, Mr. Henderson has found an angle = 150° 50′ for the same epoch. This observation being a very important one, though from its nature rather rough, I have recalculated it, and find a result agreeing within a few minutes with Mr. Henderson's, which I have accordingly retained. Probably there is an error of 10° in transcribing the result in the *Memoirs* of the Society.

The first measure employed in the direct calculations for my elements was Sir W. Herschel's in 1781, this was combined with Struve's measures in 1822 and 1836, and those by Mr. Dawes in 1842. The distance given by Struve for 1836 is 0″·257, deduced from estimations of the ratio of the axes of the oblong star with the Dorpat refractor; but in order to obtain an ellipse

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to represent accurately the other data, I found it necessary to increase this distance to 0″·41, which is perhaps worthy of remark.

The final elements of the real ellipse are—

Perihelion Passage	1836·556
Longitude of Perihelion	318° 16′·6
Longitude of Node	28 58·0
Inclination of Orbit	28 42·1
Log Semi-axis Major	0·57347
Log Mean Annual Motion	2·11166
Eccentricity	0·87715 = sin 61° 18′ 3″
Period of Revolution	167^{m}·031

Ephemeris of γ Virginis.

	Position.	Distance.
	°	″
1846·00	181·85	2·523
1847·00	179·97	2·671
1848·00	178·27	2·813
1849·00	176·73	2·948
1850·00	175·33	3·077
1851·00	174·03	3·201
1852·00	172·84	3·321

The following is the comparison of my elements with all the observations that have come to my knowledge. The differences are taken in the order computed—observed value

		Δ*l*.	Δ*ϱ*.			Δ*l*.	Δ*ϱ*.
		°	″			°	″
1718·00	Bradley	+2·0		1828·38	Struve	−2·4	−0·07
1756·00	Mayer	−4·6	−0·25	1829·16	Herschel	....	+0·08
1780·06	Herschel I.	....	+0·07	1829·22	———	−1·6	
1781·89	———	0·0		1829·39	Struve	−2·8	+0·05
1803·20	———	0·0		1830·24	Herschel	....	−0·56
1822·00	Struve	0·0	0·00	1830·38	———	−0·7	
1822·25	Herschel and South	−0·7	−0·96	1831·23	Dawes	....	−0·52
1825·32	South	+0·2	−0·83	1831·33	———	−1·8	
———	Struve	−0·9	+0·06	1831·33	Herschel	−0·8	−0·25
1828·35	Herschel	−1·4		1831·36	Dawes	−1·8	−0·48

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		$\Delta\theta$.	$\Delta\rho$.			$\Delta\theta$.	$\Delta\rho$.
		°	″			°	″
1831·36	Struve	− 4·6	0·00	1838·28	Smyth	−1·6	−0·06
1831·38	Smyth	+ 1·4	−0·11	1838·32	Dawes	−0·2	
1832·25	Herschel.....	....	+0·11	1838·43	Galle	−0·3	−0·03
1832·27	———	+ 0·2		1838·47	Galle	+1·2	+0·04
1832·30	Dawes	+ 0·2	+0·01	1839·32	Dawes	+2·1	
1832·40	Smyth	− 2·0	+0·10	1839·37	Galle	+0·6	−0·25
1832·52	Struve	− 5·0	+0·01	1839·40	Smyth	−1·5	+0·05
1833·18	Herschel	+ 0·8		1840·26	Kaiser.....	−0·5	−0·03
1833·21	———	....	−0·25	1840·29	Dawes	+0·4	−0·11
1833·23	Smyth	− 1·3		1840·44	———	+1·0	+0·09
1833·30	Dawes	+ 0·7		1841·34	Dawes	+0·2	−0·07
1833·37	Struve	+ 0·7	+0·03	1841·35	Mädler.....	+0·1	−0·22
1833·38	Dawes	....	−0·09	1842·01	Mädler.....	+0·2	+0·06
1833·44	Smyth	− 2·7	−0·21	1842·41	Dawes	0·0	0·00
1834·20	———	+ 1·3	−0·09	1843·08	Smyth	−0·5	−0·04
1834·38	Struve	− 4·6	−0·04	1843·33	Smyth	−0·1	−0·02
1834·84	Struve	+ 4·5		1843·33	Dawes	....	+0·08
1835·38	Struve	+ 7·4	+0·11	1843·40	———	−0·7	
1836·28	Dawes	− 9·0		1845·34	Smyth	+0·1	+0·20
1836·30	Smyth	−11·6		1846·28	Hind	−1·6	
1836·41	Struve	+ 0·1	+0·16	1846·32	Jacobs.....	+1·4	−0·47
1836·60	Encke	+21·4		1846·89	Dawes	−1·7	+0·06
1837·21	Smyth	+ 8·8	−0·13	1847·06	Hind	+0·2	−0·09
1837·41	Encke	+ 6·0	−0·07	1847·28	Smyth	−0·7	−0·05
1837·47	Struve	+ 4·9	−0·16				

It will be remarked, that the elements give an angle differing 21° from that observed by Encke at Berlin, in 1836; and this is, perhaps, the only instance about the time of perihelion where the difference between the observed and computed angle exceeds the probable error of observation. The disagreement in this one instance hardly affords grounds for disputing the accuracy of the elements, since the object was excessively difficult to observe at Encke's epoch.

J. R. HIND.

Mr. Bishop's Observatory,
1847, *June 11th.*

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to represent accurately the other data, I found it necessary to increase this distance to 0″·41, which is perhaps worthy of remark.

The final elements of the real ellipse are—

Perihelion Passage	1836·556
Longitude of Perihelion	318° 16′·6
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Period of Revolution	167ᵐ·031

Ephemeris of γ Virginis.

	Position.	Distance.
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1851·00	174·03	3·201
1852·00	172·84	3·321

The following is the comparison of my elements with all the observations that have come to my knowledge. The differences are taken in the order computed—observed value

		Δl.	Δr.			Δl.	Δr.
		°	″			°	″
1718·00	Bradley	+2·0		1828·38	Struve	−2·4	−0·07
1756·00	Mayer	−4·6	−0·25	1829·16	Herschel	....	+0·08
1780·06	Herschel I.	....	+0·07	1829·22	———	−1·6	
1781·89	———	0·0		1829·39	Struve	−2·8	+0·05
1803·20	———	0·0		1830·24	Herschel	....	−0·56
1822·00	Struve	0·0	0·00	1830·38	———	−0·7	
1822·25	Herschel and South	−0·7	−0·96	1831·23	Dawes	....	−0·52
1825·32	South	+0·2	−0·83	1831·33	———	−1·8	
———	Struve	−0·9	+0·06	1831·33	Herschel	−0·8	−0·25
1828·35	Herschel	−1·4		1831·36	Dawes	−1·8	−0·48

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		Δl.	$\Delta \varrho$.			Δl.	$\Delta \varrho$.
		°	″			°	″
1831·36	Struve	− 4·6	0·00	1838·28	Smyth	−1·6	−0·06
1831·38	Smyth	+ 1·4	−0·11	1838·32	Dawes	−0·2	
1832·25	Herschel.....	....	+0·11	1838·43	Galle	−0·3	−0·03
1832·27	———	+ 0·2		1838·47	Galle	+1·2	+0·04
1832·30	Dawes	+ 0·2	+0·01	1839·32	Dawes	+2·1	
1832·40	Smyth	− 2·0	+0·10	1839·37	Galle	+0·6	−0·25
1832·52	Struve	− 5·0	+0·01	1839·40	Smyth	−1·5	+0·05
1833·18	Herschel	+ 0·8		1840·26	Kaiser.....	−0·5	−0·03
1833·21	———	....	−0·25	1840·29	Dawes	+0·4	−0·11
1833·23	Smyth	− 1·3		1840·44	———	+1·0	+0·09
1833·30	Dawes	+ 0·7		1841·34	Dawes	+0·2	−0·07
1833·37	Struve	+ 0·7	+0·03	1841·35	Mädler.....	+0·1	−0·22
1833·38	Dawes	....	−0·09	1842·01	Mädler.....	+0·2	+0·06
1833·44	Smyth	− 2·7	−0·21	1842·41	Dawes	0·0	0·00
1834·20	———	+ 1·3	−0·09	1843·08	Smyth	−0·5	−0·04
1834·38	Struve	− 4·6	−0·04	1843·33	Smyth	−0·1	−0·02
1834·84	Struve	+ 4·5		1843·33	Dawes	....	+0·08
1835·38	Struve	+ 7·4	+0·11	1843·40	———	−0·7	
1836·28	Dawes	− 9·0		1845·34	Smyth	+0·1	+0·20
1836·30	Smyth	−11·6		1846·28	Hind	−1·6	
1836·41	Struve	+ 0·1	+0·16	1846·32	Jacobs.....	+1·4	−0·47
1836·60	Encke	+21·4		1846·89	Dawes	−1·7	+0·06
1837·21	Smyth	+ 8·8	−0·13	1847·06	Hind	+0·2	−0·09
1837·41	Encke	+ 6·0	−0·07	1847·28	Smyth	−0·7	−0·05
1837·47	Struve	+ 4·9	−0·16				

It will be remarked, that the elements give an angle differing 21° from that observed by Encke at Berlin, in 1836; and this is, perhaps, the only instance about the time of perihelion where the difference between the observed and computed angle exceeds the probable error of observation. The disagreement in this one instance hardly affords grounds for disputing the accuracy of the elements, since the object was excessively difficult to observe at Encke's epoch.

J. R. HIND.

Mr. Bishop's Observatory,
1847, *June 11th.*

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XVIII. *Calcul détaillé d'une Inégalité nouvelle à longue Période, qui existe dans la Longitude moyenne de la Lune. By Professor* HANSEN, *Director of the Observatory at Seeberg.*

Read May 14, 1847.

J'AI déjà communiqué, il n'y a pas long temps, à quelques astronomes deux inégalités nouvelles dans la longitude moyenne de la lune que je viens de trouver, et dont les périodes sont à très peu près 273 et 239 années. En dénotant par g, g', g'', les anomalies moyennes de la lune, de la terre, et de *Vénus*, ce sont les inégalités suivantes

$$27''{\cdot}4 \sin (-g - 16\,g' + 18\,g'' + 35^\circ\ 20'{\cdot}2)$$
$$+ 23''{\cdot}2 \sin (8\,g'' - 13\,g' + 315^\circ\ 30')$$

dont la première dépend d'un argument nouveau, tandis que la seconde a l'argument de l'inégalité à longue période dans le mouvement du soleil, que M. AIRY a trouvé le premier.

Comme le calcul de ces coefficients, qui dépendent du produit du carré et du cube de la force pertubatrice provenante du soleil par la force pertubatrice de *Vénus*, a été extrêmement pénible, à cause de l'extrême petitesse des diviseurs qui y entrent, et que ce calcul est intimement lié à mes calculs des autres inégalités de la lune, qui ne sont pas encore publiés, il ne m'est pas possible de le donner à présent. J'ai même dû ajouter dans les communications de ces coefficients, que je ne sais pas encore répondre exactement à leurs valeurs absolues, quoique j'aie lieu de croire que les valeurs rélatives en soient à très peu près exactes. En effet elles représentent à très peu près, non seulement les corrections de l'époque de la lune qui ont résulté de l'excellente comparaison des observations de Greenwich à la théorie de M. PLANA, qu'on vient d'exécuter à cet observatoire sous la direction de M. AIRY, mais elles satisfont aussi à peu près aux corrections de l'époque de la lune obtenues

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autrefois, et publiées par Laplace dans le tome troisième de la *Mécanique Céleste.*

Cependant comme la partie du premier coefficient, qui dépend de la première puissance de la force perturbatrice, peut facilement être calculée, et que l'évaluation des inégalités à longues périodes est un des points les plus importants dans l'astronomie physique, je crois que les astronomes trouveront bon que je ne tarde pas à donner ce calcul. D'ailleurs je ne manquerai pas de refaire, aussitôt qu'il me sera possible les calculs complets, afin que je parvienne aux valeurs exactes de ces coefficients, ainsi qu'aux valeurs de quelques autres plus petits et ayant des périodes moins longues, dont mes calculs m'ont déjà indiqué l'existence.

1. Soit

m'' la masse
X, Y, Z, les co-ordonnées rectangulaires par rapport à la terre } d'une planète ;

m la masse
x, y, z, les co-ordonnées rectangulaires par rapport à la terre } de la lune ;

M la masse de la terre ;
Ω la fonction perturbatrice de la lune ;

on aura la partie de Ω qui provient de l'attraction de la planète m'',

$$\Omega = \frac{m''}{M+m}\frac{1}{\sqrt{(X-x)^2+(Y-y)^2+(Z-z)^2}} - \frac{m''}{M+m}\frac{Xx+Yy+Zz}{(X^2+Y^2+Z^2)^{\frac{3}{2}}}.$$

En désignant par R la distance de la planète à la terre, et par r le rayon vecteur de la lune, on a

$$(X-x)^2+(Y-y)^2+(Z-z)^2 = R^2-2(Xx+Xy+Zz)+r^2;$$

et comme le second et le troisième terme de cette expression sont toujours beaucoup plus petits que R^2, on peut en développer la puissance $-\frac{1}{2}$ en série très-convergente. Les premiers termes de cette série sont

$$\frac{1}{R}+\frac{Xx+Yy+Zz}{R^3}-\frac{r^2}{2R^3}+\frac{3}{2}\frac{(Xx+Yy+Zz)^2}{R^5}.$$

Le premier terme de cette série ne donne rien, parcequ'il ne contient pas les co-ordonnées de la lune. Par conséquent, en l'omettant, il viendra

$$\Omega = -\frac{1}{2}\frac{m'}{M+m}\frac{r^2}{R^3}+\frac{3}{2}\frac{m''}{M+m}\frac{(Xx+Yy+Zz)^2}{R^5}.$$

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2. Maintenant il faut d'abord développer le numérateur du second terme de cette expression. Pour cet effet appelons x'', y'', z'', les co-ordonnées de la planète par rapport au soleil, et x', y', z', celles de la terre par rapport au soleil, ce qui donne

$$Xx+Yy+Zz = x''x+y''y+z''z-x'x-y'y-z'z,$$

laquelle quantité pour abréger j'appellerai C. De plus dénotant par

f l'anomalie vraie
r le rayon vecteur
ω l'arc entre le périgée et le nœud ascendant sur l'écliptique
θ la longitude de ce nœud
I l'inclinaison sur l'écliptique
} de la lune,

f' l'anomalie vraie
r' le rayon vecteur
π' la longitude du périhélie
} de la terre,

f'' l'anomalie vraie
r'' le rayon vecteur
ω'' l'arc entre le périhélie et le nœud ascendant sur l'écliptique
θ'' la longitude de ce nœud
I'' l'inclinaison sur l'écliptique
} de la planète,

on peut donner aux co-ordonnées la forme suivante

$$\begin{aligned}
x &= r\cos^2\tfrac{1}{2}\mathrm{I}\cos(f+\omega+\theta)+r\sin^2\tfrac{1}{2}\mathrm{I}\cos(f+\omega-\theta)\\
y &= r\cos^2\tfrac{1}{2}\mathrm{I}\sin(f+\omega+\theta)-r\sin^2\tfrac{1}{2}\mathrm{I}\sin(f+\omega-\theta)\\
z &= 2r\sin\tfrac{1}{2}\mathrm{I}\cos\tfrac{1}{2}\mathrm{I}\sin(f-\omega)\\
x' &= r'\cos(f'+\pi')\\
y' &= r'\sin(f'+\pi')\\
z' &= 0\\
x'' &= r''\cos^2\tfrac{1}{2}\mathrm{I}''\cos(f''+\omega''+\theta'')+r''\sin^2\tfrac{1}{2}\mathrm{I}''\cos(f''+\omega''-\theta'')\\
y'' &= r''\cos^2\tfrac{1}{2}\mathrm{I}''\sin(f''+\omega''+\theta'')-r''\sin^2\tfrac{1}{2}\mathrm{I}''\sin(f''+\omega''-\theta'')\\
z'' &= 2r''\sin\tfrac{1}{2}\mathrm{I}''\cos\tfrac{1}{2}\mathrm{I}''\sin(f''+\omega'')
\end{aligned}$$

par laquelle on voit, que j'ai pris le plan de l'écliptique pour le plan des xy; l'axe positif des x étant dirigé vers l'équinoxe du printems, et celui des z vers le nord. Au moyen de ces expressions et en faisant

$$\omega' = \pi'-\theta, \qquad \omega'' = \pi''-\theta'',$$

nous obtenons

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$$\begin{aligned}\frac{C}{r} = &-r' \cos^2 \tfrac{1}{2} I \cos (f - f' + \omega - \omega') - r' \sin^2 \tfrac{1}{2} I \cos (f + f' + \omega + \omega') \\ &+ r'' \cos^2 \tfrac{1}{2} I \cos^2 \tfrac{1}{2} I'' \cos (f - f'' + \omega - \omega'' + \omega_{,} - \omega') + r'' \sin^2 \tfrac{1}{2} I'' \cos^2 \tfrac{1}{2} I'' \\ &\quad \cos (f + f'' + \omega + \omega'' - \omega_{,} + \omega') \\ &+ r'' \sin^2 \tfrac{1}{2} I \sin^2 \tfrac{1}{2} I'' \cos (f - f'' + \omega - \omega'' + \omega_{,} - \omega') + r'' \cos^2 \tfrac{1}{2} I \sin^2 \tfrac{1}{2} I'' \\ &\quad \cos (f + f'' + \omega + \omega'' + \omega_{,} - \omega') \\ &+ 2 r'' \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I'' \cos \tfrac{1}{2} I \cos \tfrac{1}{2} I'' \cos (f - f'' + \omega - \omega'') - 2 r'' \sin \tfrac{1}{2} I \\ &\quad \sin \tfrac{1}{2} I'' \cos \tfrac{1}{2} I \cos \tfrac{1}{2} I'' \cos (f + f'' + \omega + \omega'').\end{aligned}$$

Elevant cette expression au carré, et omettant les termes qui par rapport aux inclinaisons sont d'un ordre plus élevé que le second, nous aurons

$$\begin{aligned}\frac{C^2}{r^2} = &\quad \tfrac{1}{2} R^2 - R^2 \sin^2 \tfrac{1}{2} I - r''^2 \sin^2 \tfrac{1}{2} I'' \\ &+ \tfrac{1}{2} r'^2 \cos^2 \tfrac{1}{2} I \cos (2f - 2f' + 2\omega - 2\omega) \\ &- r r'' \cos^2 \tfrac{1}{2} I \cos^2 \tfrac{1}{2} I'' \cos (2f - f' - f'' + 2\omega - 2\omega + \omega_{,} - \omega'') \\ &+ \tfrac{1}{2} r''^2 \cos^2 \tfrac{1}{2} I \cos^2 \tfrac{1}{2} I'' \cos (2f - 2f'' + 2\omega - 2\omega' + 2\omega_{,} - 2\omega'') \\ &- r r'' \sin^2 \tfrac{1}{2} I'' \cos (2f - f' + f'' + 2\omega - 2\omega' + \omega_{,} + \omega'') \\ &+ r'^2 \sin^2 \tfrac{1}{2} I \cos (2f + 2\omega - 2\omega' + 2\omega) \\ &+ (r'^2 + r''^2) \sin^2 \tfrac{1}{2} I \cos (2f + 2\omega) \\ &- r r' \sin^2 \tfrac{1}{2} I \cos (2f - f + f' + 2\omega - \omega + \omega') \\ &- r r' \sin^2 \tfrac{1}{2} I \cos (2f + f - f' + 2\omega + \omega' - \omega') \\ &- 2 r r' \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I' \cos (2f - f - f' + 2\omega - \omega - \omega') \\ &+ 2 r'^2 \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I' \cos (2f - 2f' + 2\omega - \omega + \omega' - 2\omega') \\ &- 2 r r'' \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I'' \cos (2f - f' - f'' + 2\omega - \omega' + \omega'') \\ &- 2 r' r'' \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I'' \cos (2f + 2\omega - \omega' + \omega'') \\ &+ r''^2 \sin^2 \tfrac{1}{2} I \cos (2f - 2\omega') \\ &- 2 r r' \sin^2 \tfrac{1}{2} I \cos (f + f' + 2\omega - \omega + \omega') \\ &+ r''^2 \sin^2 \tfrac{1}{2} I \cos (2f'' + 2\omega - 2\omega + 2\omega') \\ &- 2 r r' \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I \cos (f + f' - \omega - \omega') \\ &- 2 r''^2 \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I' \cos (2f'' - \omega - \omega + 2\omega') \\ &- 2 r r' \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I' \cos (f - f' - \omega - \omega') \\ &+ 2 r''^2 \sin \tfrac{1}{2} I \sin \tfrac{1}{2} I' \cos (\omega - \omega') \\ &- r''^2 \sin^2 \tfrac{1}{2} I' \cos (2f'' - 2\omega').\end{aligned}$$

En mettant cette expression de C^2 dans l'expression de Ω donnée plus haut, et en développant R^{-1} et R^{-3} ainsi que les termes différents du numérateur de Ω provenants de C^2, on obtient la fonction perturbatrice Ω développée dans une série ordonnée suivant les cosinus des multiples de l'anomalie moyenne de la lune, de celle de la terre, et de celle de la planète perturbante. D'ailleurs il faut mettre dans les arguments de cette série les termes multiples par le temps dans ω et $\omega_{,}$, qui resultent du mouvement rapide du perigée et du nœud lunaire.

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J'ai discuté un grand nombre de termes obtenus de cette manière, et qui appartiennent à des inégalités à longues périodes, mais, à l'exception d'un seul, je n'ai pas pu trouver des coefficients qui montassent à une seconde. L'argument qui en fait l'exception, et pour lequel le coefficient monte à 16″, en ne tenant compte que de la première puissance de la force perturbatrice est celui-ci

$$g+16\,g'-18\,g'',$$

g, g', g'', étant les anomalies moyennes de la lune, de la terre, et de *Vénus*.

Parmi les divers termes de l'expression précédente de C^2, ceux qui produisent les termes de l'ordre le plus abaissé dans le coefficient de l'argument mentionné sont les deux suivants,

$$\tfrac{1}{2}\,R^2+r''^2\sin^2\tfrac{1}{2}\,I''\cos(2f''+2\omega'').$$

En substituant ces termes dans l'expression de la fonction perturbatrice développée dans l'art. 1, il vient,

$$\Omega=\frac{1}{4}\frac{m''}{M+m}\frac{r^2}{R^3}+\frac{3}{2}\frac{m''+r^2}{M+m}\,\frac{r''^2\sin^2\tfrac{1}{2}\,I''\cos(2f''+2\omega'')}{R^5}.$$

3. Les termes dans R^{-3} qui dépendent de $16\,g'-18\,g''$ étant du second ordre par rapport aux excentricités et à l'inclinaison, commençons par les développer. En faisant pour abréger

$$\omega''-\omega_{,}'=2\varkappa, \qquad \omega''+\omega_{,}'=2\nu,$$

on a

$$\begin{aligned}R^2=\;& r'^2+r''^2-2r'r''\cos(f''-f'+2\varkappa)\\ &-2\sin^2\tfrac{1}{2}\,I''\,r'r''\{\cos(f''+f'+2\nu)-\cos(f''-f'+2\varkappa)\},\end{aligned}$$

et de-là il résulte d'abord

$$\begin{aligned}\frac{1}{R^3}=\;&\frac{1}{(r'^2+r''^2-2r'r''\cos(f''-f+2\varkappa))^{\frac{3}{2}}}\\ &+\frac{3\sin^2\tfrac{1}{2}\,I''\,r'r''\{\cos(f''+f'+2\nu)-\cos(f''-f+2\varkappa)\}}{(r'^2+r''^2-2r'r''\cos(f''-f'+2\varkappa))^{\frac{5}{2}}}.\end{aligned}$$

Posons maintenant

$$r'=a'(1+\zeta'), \qquad r''=a''(1+\zeta''),$$
$$f'=g'+\varpi', \qquad f''=g''+\varpi'',$$

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a' et a'' étant les demi-grands axes, et g' et g'' les anomalies moyennes de la terre et de *Vénus*. De plus faisant en général

$$\frac{(a'a'')^{\frac{n-3}{2}}}{\left(a'^2+a''^2-2\,a'a''\cos(g''-g'+2\varkappa)\right)^{\frac{n}{2}}} = \Sigma_{-\infty}^{+\infty} B_i^{(n)} \cos i\,(g''-g'+2\varkappa),$$

et mettant $(p,q)\,B_i^{(n)}$ au lieu de $a'^p a''^q \frac{d^{p+q} B_i^{(n)}}{da'^p\, da''^q}$, le théorème de Taylor donne de la manière connue

$$\begin{aligned}\frac{1}{R^3} = {} & \Sigma B_i^{(0)} \cos i\,(g''-g'+2\varkappa)+\zeta'\,\Sigma\,(1,0)\,B_i^{(0)}\cos i\,(g''-g'+2\varkappa)\\ & +\zeta''\,\Sigma\,(0,1)\,B_i^{(0)}\cos i\,(g''-g'+2\varkappa)-(\eta''-\eta')\,\Sigma i\,B_i^{(0)}\sin i\,(g''-g'+2\varkappa)\\ & +\tfrac{1}{2}\zeta'^2\,\Sigma\,(2,0)\,B_i^{(0)}\cos i\,(g''-g+2\varkappa)+\zeta'\zeta''\,\Sigma\,(1,1)\,B_i^{(0)}\cos i\,(g''-g'+2\varkappa)\\ & -\zeta'\,(\eta''-\eta')\,\Sigma i\,(1,0)\,B_i^{(0)}\sin i\,(g''-g'+2\varkappa)+\tfrac{1}{2}\zeta''^2\,\Sigma\,(0,2)\,B_i^{(0)}\cos i\,(g''-g'+2\varkappa)\\ & -\zeta''\,(\eta''-\eta')\,\Sigma i\,(0,1)\,B_i^{(0)}\sin i\,(g''-g'+2\varkappa)-\tfrac{1}{2}(\eta''-\eta')^2\,\Sigma i^2\,B_i^{(0)}\cos i\,(g''-g'+2\varkappa)\\ & +3\sin^2\tfrac{1}{2}I''\,\Sigma B_i^{(0)}\cos\left(i\,(g''-g')+g''+g'+2i\varkappa+2\nu\right).\end{aligned}$$

Des séries connues, qui donnent le rayon vecteur et l'équation du centre en fonction de l'anomalie moyenne, il résulte

$$\begin{aligned}\zeta' &= e'\cos g'-\tfrac{1}{2}e'^2\cos 2g'\\ \zeta'' &= -e''\cos g''-\tfrac{1}{2}e''^2\cos 2g''\\ \eta''-\eta' &= 2e''\sin g''-2e'\sin g'+\tfrac{5}{4}e''^2\sin 2g''-\tfrac{5}{4}e'^2\sin 2g'\\ \zeta'^2 &= \tfrac{1}{2}e'^2\cos 2g';\quad \zeta'\zeta'' = \tfrac{1}{2}e'e''\cos(g''+g');\quad \zeta'(\eta''-\eta') = -e'e''\sin(g''+g')+e'^2\sin 2g'\\ \zeta''^2 &= \tfrac{1}{2}e''^2\cos 2g'';\quad \zeta''(\eta''-\eta') = -e''^2\sin 2g''+e'e''\sin(g''+g');\\ (\eta''-\eta')^2 &= -2e''^2\cos 2g''+4e'e''\cos(g''+g')-2e'^2\cos 2g'.\end{aligned}$$

En substituant ces expressions nous aurons au moyen d'un théorème connu

$$\begin{aligned}\frac{1}{R^3} = {} & \frac{e''^2}{4}\left\{(0,2)-(4i+2)\,(0,1)+(4i^2+5i)\,(0,0)\right\}B_i^{(0)}\cos\left(i\,(g''-g')+2g''+2i\varkappa\right)\\ & +\frac{e'e''}{2}\left\{(1,1)-2(i+1)\,(1,0)+2(i+1)\,(0,1)-4(i+1)^2(0,0)\right\}B_{i+1}^{(1)}\cos\left(i\,(g''-g')+2g''+2(i+1)\varkappa\right)\\ & +\frac{e'^2}{4}\left\{(2,0)+(4i+6)\,(1,0)+(4i^2+11i)+6)\,(0,0)\right\}B_{i+2}^{(2)}\cos\left(i\,(g''-g')+2g''+2(i+2)\varkappa\right)\\ & +3\sin^2\tfrac{1}{2}I''.\,B_{i+1}^{(5)}\cos\left(i\,(g''-g')+2g''+2(i+1)\varkappa+2\nu\right),\end{aligned}$$

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où je n'ai retenu que les termes qui peuvent produire l'argument en question. Par les formules suivantes

$$(1,0)\,B_i^{(3)} = -(0,1)\,B_i^{(3)} - 3\,(0,0)\,B_i^{(3)}$$
$$(1,1)\,B_i^{(3)} = -(0,2)\,B_i^{(3)} - 4\,(0,1)\,B_i^{(3)}$$
$$(2,0)\,B_i^{(3)} = \quad (0,2)\,B_i^{(3)} + 8\,(0,1)\,B_i^{(3)} + 12\,(0,0)\,B_i^{(3)},$$

on réduit l'expression précédente à ne contenir que les quotients différentiels de $B_i^{(3)}$ par rapport à a''. Posant

$$\frac{a''}{a'} = \alpha,$$

a'' étant plus petite que a', et

$$\frac{\alpha^{\frac{n-3}{2}}}{(1+\alpha^2-2\alpha\cos G)^{\frac{n}{2}}} = \Sigma_{-\infty}^{+\infty} A_i^{(n)} \cos i G,$$

on peut réduire les $B_i^{(n)}$ et ses quotients différentiels aux $A_i^{(n)}$ et ses quotients différentiels par rapport à α. Pour cet effet, comme

$$\frac{a'a''^{\frac{n-3}{2}}}{(a'^2+a''^2-2a'a''\cos G)^{\frac{n}{2}}} = \frac{\alpha^{\frac{n-3}{2}}}{a'^3\,(1+\alpha^2-2\alpha\cos G)^{\frac{n}{2}}}$$

nous avons d'abord

$$B_i^{(n)} = \frac{1}{a'^3} A_i^{(n)},$$

partant, parceque $\frac{da}{da''} = \frac{1}{a'}$,

$$(0,1)\,B_i^{(n)} = \frac{1}{a'^3}(1)\,A_i^{(n)}$$
$$(0,2)\,B_i^{(n)} = \frac{1}{a'^3}(2)\,A_i^{(n)}$$
$$\&c.$$

$(p)\,A_i^{(n)}$ étant mis pour $\alpha^p \frac{d^p A_i^{(n)}}{d\alpha^p}$. Après avoir fait ces substitutions, on aura

$$\frac{a'^3}{R^3} = \frac{e''^2}{4}\left\{(2)-(4i+2)(1)+4i^2+5i+0)(0)\right\}A_i^{(3)}\cos\left(i(g''-g')+2g''+2ix\right)$$
$$-\frac{e'e''}{2}\left\{(2)-(4i+0)(1)+(4i^2+2i-2)(0)\right\}A_{i+1}^{(3)}\cos\left(i(g''-g')+2g''+2(i+1)x\right)$$
$$+\frac{e'^2}{4}\left\{(2)-(4i-2)(1)+(4i^2-i+0)(0)\right\}A_{i+2}^{(3)}\cos\left(i(g''-g')+2g''+2(i+2)x\right)$$
$$+3\sin^2\tfrac{1}{2}I''\,A_{i+1}^{(3)}\cos\left(i(g''-g')+2g''+2(i+1)x+2v\right).$$

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Comme le second terme de la fonction perturbatrice, donnée à la fin de l'art. 2, est déjà multiplié par $\sin^2 \frac{1}{2} I''$, il n'y a que prendre dans R^{-5} les termes indépendants des excentricités et de l'inclinaison. D'ailleurs $2\omega'' = 2\varkappa + 2\nu$, partant

$$\frac{a'^3}{R^5} r''^2 \sin^2 \tfrac{1}{2} I \cos(2f'' + 2\omega'') = \sin^2 \tfrac{1}{2} I'' \alpha A_i^{(5)} \cos\Big(i(g''-g') + 2g'' + 2(i+1)\varkappa + 2\nu\Big).$$

En faisant dans ces expressions $i = 16$, on obtient les termes de l'argument $-16g' + 18g''$. Par conséquent en répresentant l'expression suivante

$$\begin{aligned}
&\frac{e''^2}{4}\Big\{(2) - 66(1) + 1104(0)\Big\} A_{16}^{(5)} \cos(16g' - 18g'' - 32\varkappa) \\
&-\frac{e'e''}{2}\Big\{(2) - 64(1) + 1054(0)\Big\} A_{17}^{(5)} \cos(16g' - 18g'' - 34\varkappa) \\
&+\frac{e'^2}{4}\Big\{(2) - 62(1) + 1008(0)\Big\} A_{18}^{(5)} \cos(16g' - 18g'' - 36\varkappa) \\
&+ \sin^2 \tfrac{1}{2} I''\Big\{3A_{17}^{(5)} + 6\alpha A_{16}^{(5)}\Big\} \cos(16g' - 18g'' - 34\varkappa - 2\nu)
\end{aligned}$$

par

$$l \cos(16g' + 18g'' + L),$$

l étant un coefficient numérique et L un arc de cercle, il résulte

$$a'^3 \Omega = \frac{m''}{M+m} \frac{r^2}{4} l \cos(16g' - 18g'' + L).$$

Comme le facteur $\frac{m''}{M+m}$ de cette expression ne s'ajuste pas aux calculs numériques dans cette forme, il faut le transformer. Soient n le mouvement de l'anomalie moyenne de la lune, et a le demi-grand axe de son orbite, de plus n' le moyen mouvement de la terre et

$$\frac{n'}{n} = u.$$

Cela posé, la troisième loi de Keppler nous donne à très peu près, en prenant la masse du soleil pour l'unité

$$\frac{1}{M+m} = u^2 \frac{a'^3}{a^3},$$

par conséquent

$$a\Omega = \tfrac{1}{4} m'' u^2 \frac{r^2}{a^2} l \cos(16g' - 18g'' + L),$$

expression dans laquelle toutes les quantités se calculent sans difficulté.

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4. Comme la valeur trouvée pour Ω ne contient pas la longitude vraie de la lune, nous avons

$$\left(\frac{d\Omega}{dv}\right) = 0,$$

et l'expression de T, que j'ai donnée dans les *Fundamenta nova, etc.* se réduit pour l'inégalité qui nous occupe ici à

$$T = 2n\frac{\varrho}{r}\sin(f-\varphi) + ar\left(\frac{d\Omega}{dr}\right).$$

En y substituant la valeur de $\left(\frac{d\Omega}{dr}\right)$ tirée de l'expression de Ω, qu'on vient de donner, il vient

$$T = nm''\frac{\varrho}{a}\frac{r}{a}\sin(f-\varphi)\,u^2\,l\cos(16g'-18g''+L).$$

On trouve facilement

$$\frac{\varrho}{a}\frac{r}{a}\sin(f-\varphi) = \sin(g-\gamma) - \tfrac{3}{2}e\sin g + \tfrac{3}{2}e\sin\gamma + \tfrac{1}{2}e\sin(g-2\gamma) + \tfrac{1}{2}e\sin(2g-\gamma) + \text{etc.}$$

e étant l'excentricité de l'orbite lunaire et

$$\gamma = n\tau + c,$$

de même que

$$g = nt + c.$$

Mais comme nous tiendrons seulement compte ici du terme qui obtient le carré du petit diviseur

$$n + 16n' - 18n'',$$

nous n'avons bésoin que du terme $-\frac{3}{2}e\sin g$, qui est le seul qui recevra le carré du susdit diviseur. En substituant ce terme, nous aurons

$$T = -\tfrac{3}{2}nm''u^2el\sin(g+16g'-18g''+L),$$

et comme en appelant $n\partial z$ l'inégalité de la longitude moyenne de la lune, nous avons dans le cas qui nous occupe

$$n\partial z = n\iint T\,dt^2,$$

il vient enfin

$$n\partial z = \left(\frac{n}{n+16n'-18n''}\right)^2 \tfrac{3}{2}m''u^2el\sin(g+16g'-18g''+L).$$

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5. Pour le calcul numérique de cette inégalité les grands axes des orbites de la terre et de *Vénus* nous donnent

$$\log \alpha = 9{\cdot}8593375,$$

et avec cette valeur de α j'ai trouvé

$$\begin{array}{lll} (0)\ A_{16}^{(8)} = 0{\cdot}0824572 & (0)\ A_{17}^{(8)} = 0{\cdot}0612504 & (0)\ A_{18}^{(8)} = 0{\cdot}0454364 \\ (1)\ A_{16}^{(8)} = 1{\cdot}60571 & (1)\ A_{17}^{(8)} = 1{\cdot}25343 & (1)\ A_{18}^{(8)} = 0{\cdot}97488 \\ (2)\ A_{16}^{(8)} = 30{\cdot}8898 & (2)\ A_{17}^{(8)} = 25{\cdot}3056 & (2)\ A_{18}^{(8)} = 20{\cdot}6141 \end{array}$$

$$A_{16}^{(5)} = 1{\cdot}74908 \qquad A_{17}^{(5)} = 1{\cdot}36063.$$

Au moyen de ces valeurs on trouve d'abord

$$\begin{aligned} l\cos(16g'-18g''+L) = {} & \frac{e''^2}{4}\, 15{\cdot}9456\cos(16g'-18g''-32\varkappa) \\ & -\frac{e'e''}{2}\, 9{\cdot}6440\cos(16g'-18g''-34\varkappa) \\ & +\frac{e'^2}{4}\, 5{\cdot}9713\cos(16g'-18g''-36\varkappa) \\ & +\sin^2\tfrac{1}{2}I''\ 11{\cdot}6729\cos(16g'-18g''-34\varkappa-2\nu). \end{aligned}$$

On a de plus

$$\begin{array}{ll} \log e'' = 7{\cdot}83644 & \log e' = 8{\cdot}22510 \\ \varpi'' = 128^\circ\,43'\,6'' & \varpi' = 99^\circ\,30'\,29'' \\ \theta'' = 74\ 51\ 41 & \\ \log\sin\tfrac{1}{2}I'' = 8{\cdot}47114. & \end{array}$$

Partant

$$\begin{array}{ll} 2\varkappa = 29^\circ\,12'\,37'' & 2\nu = 78^\circ\,30\ 13'' \\ 32\varkappa = 107\ 21\ 52 & \\ 34\varkappa = 136\ 34\ 29 & \\ 36\varkappa = 165\ 47\ 6 & \\ 34\varkappa+2\nu = 215\ 4\ 42 & \end{array}$$

$$\begin{aligned} l\cos(16g'-18g''+L) = {} & \left.\begin{array}{r} -0{\cdot}0000560 \\ +0{\cdot}0004035 \\ -0{\cdot}0004080 \\ -0{\cdot}0083641 \\ \hline -0{\cdot}0084246 \end{array}\right\}\cos(16g'-18g'') \\ & \left.\begin{array}{r} +0{\cdot}0001791 \\ -0{\cdot}0003819 \\ +0{\cdot}0001034 \\ -0{\cdot}0058737 \\ \hline -0{\cdot}0059731 \end{array}\right\}\sin(16g'-18g') \end{aligned}$$

ou

$$l\cos(16g'-18g''+L) = (8{\cdot}01399)\cos(16g'-18g''+144^\circ\,39'{\cdot}8),$$

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c'est-à-dire

$$\log l = 8{\cdot}01399$$
$$L = 144^\circ\ 39'{\cdot}8.$$

On voit par ce détail que, c'est surtout l'inclinaison entre les orbites de la terre et de *Vénus* dont dépend la grandeur du coefficient, l'effet des excentricités étant beaucoup moins considérable. De plus, en analysant l'effet des deux termes multipliés par $\sin^2 \frac{1}{2} I''$, on voit que celui qui dépend de $\alpha A_{16}^{(5)}$ est à peu près le double de celui qui dépend de $A_{17}^{(5)}$. Par conséquent la partie du coefficient provenante du terme de Ω originalement divisé par R^5 donne à peu près deux tièrs de la valeur complète du coefficient de cette inégalité.

Nous avons de plus, lorsqu'on prend l'année Julienne de $365\frac{1}{4}$ jours pour unité de temps,

$$n = 17179157''{\cdot}4$$
$$n' = 1295977{\cdot}38$$
$$n'' = 2106641{\cdot}29$$

ainsi

$$n = 17179157''{\cdot}4$$
$$16\,n' = 20735638{\cdot}1$$
$$-18\,n'' = -37919543{\cdot}2$$
$$n + 16\,n' - 18\,n'' = -\ 4747{\cdot}7$$

auquel nombre de secondes correspond à peu près la période de 273 années Juliennes. Maintenant on trouve

$$\log \frac{n}{n + 16\,n' - 18\,n''} = 3{\cdot}55852_n$$
$$\log u = 8{\cdot}87759.$$

On a d'ailleurs

$$\log e = 8{\cdot}73958,$$

et mes recherches sur le mouvement du soleil m'ont donné pour la masse de *Vénus*

$$m'' = \frac{1}{408134},$$

ainsi en secondes

$$\log m'' = 9{\cdot}70363.$$

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A présent nous avons tous les nombres pour calculer le coefficient d'après la formule donnée à la fin de l'art. 4,

$$\log\left(\frac{n}{n+16n'-18n''}\right)^2 = 7{\cdot}11704$$

$$\log\tfrac{3}{4} = 9{\cdot}87506-10$$
$$\log m'' = 9{\cdot}70363-10$$
$$\log u^2 = 7{\cdot}75518-10$$
$$\log e = 8{\cdot}73958-10$$
$$\log l = 8{\cdot}01399-10$$
$$\text{Somme} = 1{\cdot}20448$$

d'où il résulte

$$n\delta z = 16''{\cdot}01 \sin(g+16g'-18g''+144^\circ\,39'{\cdot}8),$$

ou en transformant l'argument en sorte qu'il augmente avec le temps,

$$n\delta z = 16''{\cdot}01 \sin(-g-16g'+18g''+35^\circ\,20'{\cdot}2).$$

En vertu des variations séculaires des excentricités et des périhélies de la terre et de *Vénus* ce coefficient reçoit un petit changement, et obtient en outre un terme multiplié par le temps hors le signe de sinus.

Après avoir tenu compte de ces variations, j'ai obtenu au lieu de la valeur précédente la suivante

$$n\delta z = 15''{\cdot}79 \sin(g+16g'-18g''+144^\circ\,37'{\cdot}4)$$
$$+ 0{\cdot}00261\, t \sin(g+16g'-18g''+57^\circ\,31'),$$

d'où l'on voit que les termes provenants de cette considération ne deviennent sensibles qu'après plusieurs siècles avant ou après l'époque. Cependant le cube des forces perturbatrices, ou plutôt le produit du carré et du cube de la force perturbatrice du soleil par la force perturbatrice de *Vénus*, ajoute une quantité sensible à ce coefficient, et rend en même temps sensible le coefficient de l'argument $8g''-13g'$, qui, en tenant seulement compte de la première puissance de la force perturbatrice, serait insensible dans le mouvement de la lune.

En outre, l'inégalité qu'on vient de calculer est remarquable en ce qu'elle dépend des plus hauts multiples des anomalies moyennes qu'on ait considerés jusqu'ici, et qu'elle a la période la plus longue par rapport au temps périodique du corps troublé, qu'on connaisse jusqu'à présent.

P. A. HANSEN.

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REPORT OF THE COUNCIL OF THE SOCIETY

TO THE

TWENTY-SIXTH ANNUAL GENERAL MEETING,

FEBRUARY 13, 1846.

In presenting to you the Report of our proceedings during the first year of the second quarter of a century of the Society's existence, your Council feel that there is much reason to congratulate you on the general state of our own affairs, as well as on the progress of our science. It is with the sincerest pleasure they announce, that the activity of the Society, under circumstances of some embarrassment, has not suffered any diminution. These circumstances will presently be more particularly described.

The Report of the Auditors, which is subjoined, will shew the state of the finances of the Society:—

Receipts.

	£.	s.	d.
Balance of last year's account ..	195	8	9
1 year's dividend on £900 Consols	26	4	4
6 months' ditto on £2143 14*s.* 10*d.* New 3¼ per Cents	33	16	5
6 months' ditto on £2206 3*s.* 5*d.* New 3¼ per Cents	34	16	2
On account of arrears of contributions	109	4	0
Carried forward ..	£399	9	8

Expenditure.

	£.	s.	d.
Cash paid for Investment of 4 compositions	84	0	0
Mr. Harrison, for stationery	4	6	6
Mr. Vickery, for law expenses ..	9	8	0
Mr. Basire, for engraving	4	8	6
Barclay and Co., for printing Monthly Notices, &c. for Session 1845–46	70	7	6
Carried forward ..	£172	10	6

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Receipts.

	£	s.	d.
Brought forward....	399	9	8
48 contributions (1845–46)	100	16	0
3 ditto (1846–47)	6	6	0
3 compositions	63	0	0
11 admission fees.....	23	2	0
9 first year's contributions.....	17	17	0
Sale of Memoirs.....	45	18	0
	£656	8	8

Expenditure.

	£	s.	d.
Brought forward....	172	10	6
Cubitt and Co. for fitting up bookcases	29	15	0
Lieut. Stratford, for library expenses.....	6	5	0
R. Harris, for 1 year's salary as Assistant-Secretary	100	0	0
R. Harris, for commission on collecting £303 3*s*.....	15	3	2
Charges on books, and carriage of parcels	2	13	8
Postage of letters	20	2	9
Porter's and charwoman's work, &c.....	9	19	0
Tea, sugar, cakes, &c. for the evening meetings	13	13	0
Coals, candles, &c.....	12	18	6
Sundry disbursements by the Treasurer	8	15	1
Taxes { Land tax ..... 3 2 6 / Window duty.. 5 4 9	8	7	3
Balance in the hands of the Treasurer (January 22, 1846).	256	5	9
	£656	8	8

The assets and present property of the Society are as follow:

Balance in the hands of the Treasurer £256 5 9

Arrears, Jan. 28, 1846.

			£	s.	d.
3	contributions of 7 years' standing		44	2	0
3	———	of 6 ditto	37	16	0
4	———	of 5 ditto	42	0	0
1	———	of 4 ditto	8	8	0
1	———	of 3 ditto	6	6	0
19	———	of 2 ditto	79	16	0
26	———	of 1 ditto	54	12	0
			273	0	0

£900 3 per Cent Consols.

£2206 3*s*. 5*d*. New 3½ per Cent Annuities.

Unsold Memoirs of the Society.

Various astronomical instruments, books, prints, &c.

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The progress and present state of the Society, with respect to the number of its Fellows and Associates, may be best seen from the following abstract, continued from the Report of last year, viz.:

	Compounders.	Annual Contributors.	Non-residents.	Patroness, and Honorary.	Total Fellows.	Associates.	Grand Total.
February 1845..	102	125	75	5	307	37	344
Since elected...	18	10	..	..	28	..	28
Deceased.....	−2	−2	−1	..	−5	..	−5
Resigned.....	..	−2	..	..	−2	..	−2
Removals.....	+3	−3	..	..	..	..	..
February 1846..	121	128	74	5	328	37	365

The instruments belonging to the Society are distributed in precisely the same manner as recorded in the Annual Report of last year, viz.:

The *Harrison* clock,
The *Owen* portable circle,
The *Owen* portable quadruple sextant,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Beaufoy* clock,
The *Herschelian* 7-foot reflector,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,

are in the apartments of the Society.

The brass quadrant, said to have been *Lacaille's*,

is in the apartments of the Royal Society.

The Standard scale

is in the charge of the Astronomer Royal, with the consent of the Council, to be used in the formation of a new standard measure, under the direction of the Standard Commission.

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The remainder of the instruments are lent, during the pleasure of the Society to the several parties undermentioned, viz.:

The *Fuller* theodolite, to the Lords of the Admiralty.
The other *Beaufoy* clock,
The two invariable pendulums, } to the Royal Society.
The *Lee* circle, to Lord WROTTESLEY.
The Wollaston telescope, to Professor SCHUMACHER.
The Universal quadrant by ABRAHAM SHARP, the Variation transit, and the 7-foot *Gregorian* reflecting telescope, recently bequeathed to us by our late Fellow, Mr. SHEARMAN,

are in the apartments of the Society.

The printing of the fifteenth volume of the *Memoirs*, which it was hoped would have appeared long since, has been retarded by the illness of the Assistant-Secretary. The Council are, however, glad to report that it is now published. While mentioning this subject, the Council beg to remind the Fellows of the desirableness of communicating speedily any change of residence or title which may happen, in order that the list may be kept in a state of correctness. It is also desirable that Fellows who may hear of the death of any Fellow who is not much seen amongst us should apprise the Secretary of the event.

The sixth volume of *Monthly Notices* was completed with the last session.

It was mentioned in the last Annual Report, that Mr. SHEEPSHANKS had borrowed the portrait of Mr. BAILY, for the purpose of having it engraved. The engraving, by Mr. LUPTON, is now finished in a beautiful style, and Mr. SHEEPSHANKS has presented a copy to every one of the Fellows. If any one present be not aware of this, your Council have the pleasure of informing him that his copy will most probably be ready about the end of the present month, and will be given up to his order. You will, undoubtedly, feel that it would be impossible to present to one of our Fellows, as such, a more acceptable memorial of his connexion with the Astronomical Society; and you will join the Council in expressing our obligations to Mr. SHEEPSHANKS, not only for the copies of the valuable print itself, but for the addition to the

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recorded memorials of a man whose memory must be an object of almost filial veneration to this Society as long as it preserves its own existence.

At the last annual meeting, the Astronomer Royal, then President, in announcing the reasons upon which the Council had awarded the medal to Captain SMYTH for his *Bedford Observations*, made some remarks upon the difficulty which arose from the original observations not being before the Society, and concluded by expressing strongly his opinion that those observations should be given up to the Council, that they might have full means of justifying their award. The slips of paper containing the results of the measures had been transferred to Dr. LEE, with the Bedford instruments. In March, however, they were forwarded to our Secretary by Captain SMYTH, with the consent of Dr. LEE, and are now the property of the Society, which owes its thanks to both the gentlemen named, for their ready accession to the President's request. The Council, fully concurring in the Astronomer Royal's remarks, have great satisfaction in making this announcement.

It has been for some time understood that it was the intention of our respected colleague, Dr. PEARSON, to bequeath to the Society the stock and plates of his most valuable work on *Practical Astronomy*. Some months since he expressed his desire that the Society should take charge of 500 copies, till such time (a distant one we hope) as his bequest should take effect. This request being readily granted, the copies in question were deposited in our apartments: the plates still remain in Mr. WOODFALL's custody.

Among the other presents received during the past year may be mentioned the manuscript observations of the Paramatta Catalogue of 7385 Stars, presented by Sir THOMAS BRISBANE.

To Mr. TURNOR the Society is indebted for the gift of the curious manuscript Almanacs described in the recently published volume of our *Memoirs* by our lamented Assistant-Secretary.

The Society has to regret the loss, by death, of the following Fellows:— Admiral GREIG, Lieutenant A. P. GREENE, General Sir ROBERT DUNDAS, CHARLES SHEARMAN, Esq., and the Rev. HENRY CODDINGTON.

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Alexis Greig was an Admiral in the Russian Imperial Navy, Member of the Imperial Council, Senator of the Empire, and knight of all the Russian orders. This distinguished officer was ever anxious to promote the education of those under his command, and, aware of the advantages of a practical acquaintance with astronomy, he founded the well-known observatory of Nicolajef on the Black Sea, now so ably conducted by M. Knorre. In his latter years he was recalled from active service to St. Petersburg, where he was appointed a constant member of the Council of the Empire, and became very useful in forwarding the pursuit of knowledge. The Emperor named him President of the Scientific Commission to which the founding of the great observatory of Pulkowa was intrusted: and there is no question that the successful building and endowment of this establishment are mainly owing to his care and intelligent guidance.

Admiral Greig, who has an additional claim to our regard in being the brother-in-law of our esteemed Honorary Member, Mrs. Somerville, after a life of honour and respect, died at St. Petersburg on the 30th of December, 1844; and was buried with every acknowledgment of his rank, services, and worth. It will be recollected with interest, that he was one of the very first Members of this Society; and that he ever expressed a lively regard for its welfare and proceedings. In proof of this, we need but remind the Members of his munificent present to the Society of the universal instrument by Reichenbach, which has been mentioned in the list of our instruments.

Lieutenant Augustus Percival Greene, of the Royal Navy, was a young officer of much promise; for, though cut off in early life, his attainments were sound and extensive. He passed his examination for a commission in the year 1838, and went out to India in the Cornwallis, of 72 guns; where, in 1842, he was promoted to the rank of lieutenant for his services on the coast of China. He was now appointed to the surveying-ship Plover; and it was quickly found that his skill in mathematics, practical astronomy, and drawing, together with his habits of industry and perseverance, rendered him a very valuable assistant in the responsible duties the vessel was officially engaged in. While thus actively and usefully employed, he was attacked with a remittent fever at Amoy, which carried him off in fifteen days, on the 2d of December last. Captain Collinson, the commander of the Plover,

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announced this melancholy and unexpected event with great feeling, concluding in these words:—"His remains were consigned to their last home, under a large tree in the cemetery upon the island of Kolongsu, attended by the consul and the greater part of the military and the merchants, most of whom were well acquainted with his worth, on the morning of the 4th (Dec. 1845); and it is the intention of Lieutenant BATE and myself to place a stone over the remains of a companion whose loss we feel most deeply."

Lieutenant-General the Hon. Sir ROBERT LAWRENCE DUNDAS, K.C.B., was an officer equally distinguished for his attachment to science, and his attention to military duties. He was the sixth son of THOMAS, Lord DUNDAS, by Lady CHARLOTTE WENTWORTH, sister of Earl FITZWILLIAM. He was born in 1780, and entered the army at the early age of sixteen; but such were his acquirements, that he served with distinction as an engineer officer in the arduous campaign in North Holland in the year 1799. Shortly after the return of that expedition he embarked for Egypt, and was present in the memorable battle of the 21st of March, 1801. On the surrender of General MENOU, he joined some other officers in a successful endeavour to decipher the Greek inscription on the granite pedestal of the monument outside the walls of Alexandria, which is usually termed Pompey's Pillar; but which, after visiting it for several days successively at the most favourable hour, when the rays of the sun first strike obliquely on the plane of the letters, they found to belong to the reign of Diocletian. In 1805, Captain DUNDAS was sent into the north of Germany with the Royal Staff Corps; and he subsequently served in the Peninsula under progressive advancement, where his behaviour in nine distinct actions gained him the second class decoration of the Bath, a cross and three honorary clasps.

Since the peace, General DUNDAS largely indulged his literary and scientific tastes, and in the application and use of instruments, has proved himself a worthy descendant of the founder of the Zetland family. He died in November 1844, at the age of 64 years.

Mr. CHARLES SHEARMAN was for many years a Fellow of the Society. He was attached to astronomy, and has bequeathed to the Society the following instruments:—1. A graduated brass plate, with a description, in which

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it is called, "the Universal Quadrant of ABRAHAM SHARP." 2. A Variation Transit, or Altitude and Azimuth Instrument, by DOLLOND. 3. A 7-foot Gregorian Reflector, by BANKS.

The Rev. HENRY CODDINGTON took his degree at Cambridge in 1820, with the honour of senior wrangler. He obtained a fellowship at Trinity College, and also a sub-tutorship, from which in time he retired to the college living of Ware, in Hertfordshire. In science, his principal attention was devoted to optics, on which subject all his publications treated, except, we believe, a small anonymous tract which he wrote on the principles of the Differential Calculus. His first work on optics was an elementary treatise, the first in our language which introduced the Cambridge student to modern methods: it was published in 1822, and, though useful, did not exhibit much originality either of matter or manner. His second work, published in two parts at Cambridge (1829 and 1830) is that by which his name as an investigator in mathematical physics will be preserved. The second part treats of optical instruments in an elementary manner; but the first is the most complete investigation of the geometrical laws of reflection and refraction, in the case of mirrors and lenses, which exists in our language. Taking for his basis the then recently published investigations of Mr. AIRY on the path of a ray, whether of a direct or oblique pencil, Mr. CODDINGTON exhibited this very complicated subject in a manner which renders it accessible to any student of moderate mathematical attainments and sufficient industry.

Mr. CODDINGTON died at Rome, whither he had gone for the benefit of his health, in the course of last year. He was much esteemed for his courtesy of manners and benevolence of disposition, as well as respected for his various attainments. He was a Fellow of this Society from its foundation.

Though the Count CASSINI had retired from the pursuit of astronomy long before the formation of this Society, and was not, therefore, one of our associates, it is, nevertheless, impossible to pass over in silence the extinction of this ancient hereditary race of astronomers. He died on October 18, 1845, aged 97. From 1671 to 1793, that is, from the foundation of the Paris Observatory till the period of the Revolution, it was occupied by the four CASSINIS in succession. The last of these, the Count CASSINI of whom we

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are now speaking, was driven out by the National Convention, at the time when he was pressing upon them the reconstruction of the Observatory and the introduction of modern instruments. Though an hereditary dynasty of astronomers was not found very favourable to the interests of astronomy, as tending to perpetuate the ideas and methods of its founder, in lieu of introducing acknowledged improvements from time to time, family groups of distinguished philosophers must always be objects of peculiar interest to the historical inquirer. Community of name and blood magnifies even the aggregate amounts of the successes of the CASSINIS, the BERNOULLIS, the LEMONNIERS, the MARALDIS, the LALANDES, and the HERSCHELS; nor is it without a feeling of satisfaction that we take notice of five of these families having been families of astronomers.

The fifth CASSINI, by name HENRI, son of Count CASSINI, was a judge of the Cour Royale, and was well known for his extensive knowledge of natural history. He died of the cholera at Paris in 1833.

Not long after the last annual meeting, our valuable Assistant-Secretary, Mr. HARRIS, was seized with a complaint in the knee-joint, which almost wholly incapacitated him from attending to business. It was at one time thought that he might have been restored to health, but, unfortunately, just at the time when the local complaint seemed to yield to medical treatment, rapid consumption came on, and terminated his life on the 25th of December. Mr. HARRIS was a native of Shipton, near Burford, in Oxfordshire, and was, at the time of his death, in his 35th year. After being occupied from the age of 19 as a schoolmaster at Greenwich, he passed, in August 1841, into the employment of the Astronomer Royal, in whose opinion he soon ranked very high as a valuable computer and trustworthy agent. In November 1843, he was appointed to fill the vacancy in the Assistant-Secretaryship made by the resignation of Mr. HARTNUP; so that the Council had but time to form the decided opinion they now express of his worth and usefulness, before the first appearance of the disorder which terminated his life. Mr. HARRIS was a well-informed and even accomplished man, and a successful student of the arts of painting and music. He was also attached to the literature of astronomy, as well as to the practice of its methods. He is the author of a paper on an ancient almanac, which appears in the recently published volume.

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The Council feel that it will not be easy to supply his place with a person possessed of so much combined power of being useful to the Society and to the science of astronomy.

It is with much regret that the Council announce the retirement of the Rev. R. MAIN from the office of Secretary, which he has now held for five years. In addition to the zeal on behalf of the Society which has actuated him, in common with others, Mr. MAIN has brought to the duties of his office a close acquaintance with practical astronomy, as well as theoretical, and the habits of order demanded by a daily attention to astronomical duties more onerous than those of our Secretaryship. So heavy, indeed, are these last, that the Council acknowledge peculiar obligations to the gentleman who, residing at so great a distance, and pressed by public calls of such magnitude, has for years found time to be the constant superintendent of the routine of our business, and a regular attendant at our meetings. The Council have the satisfaction of announcing that Mr. SHEEPSHANKS has undertaken the vacant office, the one of all others which it is most difficult to supply.

The post of Director of the Edinburgh Observatory, vacant by the lamented death of Mr. HENDERSON, has been conferred by Government on Mr. CHARLES PIAZZI SMYTH, the second son of our President, who, as is well known to all here present, has been engaged for the last ten years as assistant to Mr. MACLEAR, at the Cape of Good Hope. Mr. PIAZZI SMYTH has lately arrived in England, and is now settled at Edinburgh, and engaged in the performance of his duties. Educated in so good a school, and having hitherto shewn so much zeal in the pursuit of practical astronomy, we cannot doubt that he will do additional honour to the name which he bears; and in that persuasion, the Council feel sure this meeting will join them in congratulating our President on the prospects which have opened to his son.

In the month of May last, a proposition was made to the Council, by the remaining members of the Spitalfields Mathematical Society, then on the point of dissolution, to present to the Society any portion of their library which might be deemed acceptable, on condition that the use of the volumes should be allowed to the members during their lives. The Mathematical Society was well known to most of our Fellows; it was established in 1717,

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and for a long time contributed to keep up a taste for exact science among the residents in the neighbourhood of Spitalfields. Its antiquity, the circumstance of its having numbered such men as DOLLOND and THOMAS SIMPSON among its members, and the access which its valuable library gave to such books as a private individual rarely possesses, well entitled it to rank among the scientific institutions of the country. When the Council understood that this ancient society was on the point of dissolution, and received private information, in conjunction with the offer above named, that its members were desirous to keep the library together in some public institution, a Committee was appointed to confer with the members, and to examine the books. That Committee reported in favour of incorporating the Mathematical Society with our own, in the following manner: That the books, records, and memorials of the Mathematical Society should be made over to the Astronomical Society; that all the members of the former society not already Fellows of this Society should be thereupon elected Fellows without payment of any contribution whatsoever; and that such members of the former society as were already among our Fellows, and liable to the payment of annual contribution, should thereupon be exempt from such liability for the future. The Council adopted the conclusions of this Report, and decided upon recommending their adoption to a Special General Meeting of the Society. The calling of this meeting was necessary, not only because it would not have been proper to have concluded so unusual a bargain without giving the Society at large an opportunity of expressing its opinion, but because, from the conditions agreed upon, it became necessary to suspend, so far as the elections were concerned, the existing bye-laws of our Society. This General Meeting was accordingly held on the 13th of June last; the recommendation of the Council was unanimously agreed to, and sixteen gentlemen (three out of nineteen remaining members of the Mathematical Society being already on our list) were elected Fellows, their right of admission being consequent on the fulfilment of their part of the agreement. The books, &c. were speedily delivered at our apartments, and they are now arranged on shelves in the basement story.

In proposing the above arrangement, the Council were actuated by motives which rendered it of little moment whether the library, &c., which formed the equivalent for the contributions of the Fellows to be elected, was

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or was not worth the money value of those contributions. It is, nevertheless, satisfactory to be able to state, that the addition thus made to the Society's library is of great value and extent. The number of books is as follows: folios, 76; quartos, 622; octavos, 1444; duodecimos, 314; with about 131 works uncatalogued. Among these there is a considerable number of volumes of worth and rarity.

And, while on this subject, the Council must not forget to state the obligations under which the Society lies to Mr. STRATFORD, who, with great labour, superintended the comparison of these books with the Mathematical Society's Catalogue, and the due arrangement of them upon the shelves. This assistance, valuable at any time, was doubly so from the unfortunate state of health of the Assistant-Secretary, which prevented him from giving any aid whatever. Mr. STRATFORD has also undertaken the preparation of a new Catalogue, which shall give the whole of the library, including the recent additions; and in which the books obtained from the Mathematical Society will have a distinctive mark. When this Catalogue is completed, it is the intention of the Council to print it forthwith, for the use of the Fellows.

The Council have awarded the gold medal to the Astronomer Royal for his recent publication of the reduction of the Greenwich Planetary Observations from 1750 to 1830. This work was described generally in the last Annual Report, as about to appear. The President will undertake, at the close of the ordinary proceedings of this day, to describe and justify the grounds on which the award was made. The Council will add nothing except their entire conviction, that it rarely happens that so valuable a present is made by the practical to the theoretical astronomer; and seldom, indeed, that it is made by one who unites both characters in so remarkable a degree.

The corresponding series of lunar observations is now so far advanced, that only a small revision of some of the later years is wanting. Ten years' reductions in Right Ascensions and North Polar Distance are printed, the Government having supplied the necessary funds; and the formation of the equations for the correction of the elements is in progress. It is remarkable that, though all the lunar tables now existing to which observation has

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contributed, or which have not been formed from theory alone, have been founded on data procured from Greenwich, that Observatory is yet able to shew that its records are not exhausted. Singularly connected as it has always been with the progress of lunar astronomy, its history has never presented so remarkable an epoch as the present time. The reduction, in the most systematic and usable form, of its old meridian observations, is the work of the Astronomer Royal, who suggested and undertakes the extra-meridional course of observation mentioned in the last Report.

The altitude and azimuth instrument intended for this purpose has now left the engineer's hands, and is in those of Mr. SIMMS, for the completion of the micrometers, levels, graduations, &c. It is in a very forward state. The peculiar tables which the reduction of the observations will require are in preparation, and no long time will elapse before it is in use.

The connexion of Pulkowa, Altona, and Valentia with the Observatory of Greenwich has the calculations now completed. The result for Pulkowa is not yet printed; that for Altona differs very little from the one which was found many years ago. The result for Valentia has been compared with that derived from Colonel COLBY's survey, the elements for the figure of the earth being those which were given some years ago by the Astronomer Royal, in the *Encyclopædia Metropolitana*. It appears that the geodetic longitudes of Liverpool and Kingston are a very little too large, that of Valentia a very little too small; being just what would take place if the ordinary assumptions employed in determining the figure of the earth were disturbed by an unknown source of attraction beneath the surface of Ireland. A memoir on these results is now in preparation by the Astronomer Royal.

The ordinary star-observations at Greenwich have been, during the past year, in a great measure devoted to filling up the blanks in one element (whether Right Ascension or North Polar Distance) which exist in the recently published catalogue of 1439 stars.

By information received from Colonel ESTCOURT, who is employed upon the survey of the North American boundary, it appears that the latitudes of various points have been obtained by the use of excellent twelve and fifteen-

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inch altitude and azimuth instruments. The differences of longitude have been found (the country presenting no more such difficulties as those described in last year's Report) by instantaneous signals of gunpowder flashes compared with transit observations, made at intervals of three minutes. The accuracy of the results may be inferred from this statement, that the extreme discordance of the determinations of difference of longitude from sixty signals was only four-tenths of a second. The intermediate parts have been filled up by the usual operations of surveying. There is no doubt that the map of this wild tract will be comparable in accuracy to that of any country in Europe. A general map is in preparation on a scale of four inches to a mile, with special maps on that of twelve inches to a mile.

At Cambridge, the observations of comets and of the new planet have, for the present, superseded those of double stars. The volume for 1842 has just been published. Besides the usual matter, it contains the accurate places of a large number of double stars. During the last year, the meridian observations were confined to stars; for the most part, either double stars or stars observed with comets. By this means Professor CHALLIS hopes to complete a second Cambridge Catalogue, at the same time that he effects the reduction of the large number of comet observations which he has taken.

The last year has been marked to the astronomer by the appearance of the Catalogue of the British Association. This inestimable volume, which contains the mean places for 1850 of 8377 stars, with all the requisite aids for obtaining their apparent places for any other epoch, is an extension and completion of the Catalogue published in 1827 by this Society, and so well known as the Astronomical Society's Catalogue. Both were published under the same superintendence, and both bear the name of FRANCIS BAILY on their title-pages; but though upon the same plan, yet the second appears with such additions and improvements as render it a new work. For, first, the number of stars is nearly trebled; secondly, from the particular attention which has been paid of late years to this branch of astronomy (chiefly owing, it may be said, to our own Catalogue), the accuracy of the mean places has been immensely increased; thirdly, the secular variations of the precession have been added, as well as the annual proper motions, so far as they are known; and, lastly, in the nomenclature, in the exact citation of authorities,

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and, it must be added, in the beauty of the getting up, every thing has been done which the greatest experience and zeal could suggest.

The preface contains a clear account of the process of composing the catalogue, of the formulæ employed or to be employed, of the motives which directed the author in his variations from antecedent authorities,— in short, all that would have been expected from FRANCIS BAILY on the subject which had occupied him principally, though not exclusively, for a quarter of a century. The work was completed, with the exception of some notes, and partly printed, at the author's decease, and the task of bringing the whole to the desired end has been ably performed by his friend and coadjutor in the labour of constructing and printing our former Catalogue, Lieut. STRATFORD.

But though this volume is, and will be for years, the text-book of the practical astronomer, it must not be received as a perfect work, but as a step — an immense step, to be sure — towards perfection. Our knowledge of the sidereal heavens is yet in its infancy. That every thing must be in motion, in accordance with the laws of gravitation, may indeed be looked upon as demonstrated; but, except the broad notion that our system is moving towards some point of the present apparent heavens, the knowledge of the approximate distances of two stars, certainly of 61 *Cygni* and probably of α *Centauri*, nothing is accurately known of the things which must become data before the velocity and direction of motion of the centre of gravity of our system can be determined. The late Astronomer Royal, Mr. POND, was of opinion, and his judgment has recently been confirmed by our illustrious associate BESSEL, that a variation in the proper motions of some stars has been detected by observation; and if this be confirmed, the first step is made.* But the exceeding minuteness of the difference of motions, which themselves require many years to rise to an appreciable amount, presents a difficulty only to be overcome by immense labour and the most scrupulous accuracy. For each star there are required, at least, three different and well-defined epochs; and where are we, as yet, to look for such data?

* It may be worth consideration whether a complete recomputation of all BRADLEY's observations of stars might not be advantageous. The *Fundamenta*, as edited by BESSEL, does not include *all* the observations, and the epoch of the observations is not given. This most important element was first added by the present Astronomer Royal, and the yearly partial catalogues

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The Council cannot but mention what is one of the most remarkable astronomical events of the year, though perhaps no one of the parties concerned in it gave our science a thought. They allude to the repeal of the excise duty on glass, which might be called with perfect truth an astronomical window-tax. Every person here present must be aware that the nature of the regulations under which it was found or thought necessary to place the manufacture of this important article, rendered experiments for the improvement of optical glass almost impracticable and a great deal too expensive. It may now be confidently hoped, that in a few years our country will not be obliged to admit that we are surpassed by foreigners in this particular. But it must be remembered that it is not likely that the object will be attained, unless systematic attention be directed towards it. The Council hope, therefore, that those who feel interested in astronomy, and who have directed their attention to the chemistry of manufactures, will not forget to keep their thoughts fixed upon the great importance of procuring good optical glass in large quantities. The end to be gained is not merely the acquisition of large object-glasses in greater numbers. The want of sufficient supply, easily obtained, is found in regard to smaller lenses, and no one can positively say, or even reasonably suppose, that the whole manufacture is not capable of great improvement.

An attempt has been made by Mr. Simms to furnish the object-glass for the Liverpool equatoreal from his own workmanship; but the indifferent quality of all the optical glass which is on sale (the Munich unworked glass is not to be bought) did not allow him to attain the degree of perfection which he aspired to. In this dilemma, the Town Council have requested the Astronomer Royal to purchase the object-glass, tube, and eye-glasses, from Merz and Co. of Munich. The mounting which the Astronomer Royal proposes to adopt is that sometimes called the English mounting,— namely, a transit telescope between two supports, which, united at the top and bottom, form the polar axis. Mr. Airy considers that by making these supports of

which appear in the annals of our observatories are exceedingly valuable from supplying the date. In making the above suggestion we do not forget what we owe to Bessel's *Fundamenta*, nor how much of the reasonableness of our expecting yet more benefit from Bradley's observations lies in the consequences of the impulse which the publication of that mighty work gave to accurate astronomy, and the means which it supplies for still further improvement.

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sheet-iron, having a section something like that of a chord and arc, he will get great stiffness and solidity with moderate weight, and at a comparatively small expense. When thus equipped, the Liverpool Observatory will doubtless furnish a plentiful supply of valuable extra-meridional observations. This excellent institution will then be a model of what the science may reasonably look for at the hands of those who attend to the interests of navigation at the principal ports, — namely, ample means of giving time and regulating chronometers, with power to the superintendant of employing the time he has to spare about that class of observations in which a private observer can make himself really useful to the progress of the science.

It was mentioned in last year's Report that Mr. SHEEPSHANKS had undertaken to finish the construction of the standard yard measure commenced by Mr. BAILY. On examining the state of progress (for Mr. BAILY's last illness seized him when he had hardly commenced his operations) and the points which were left not satisfactorily determined by preceding measures, Mr. SHEEPSHANKS, with the consent of the Committee, resolved upon a more extensive series of experiments than was at first contemplated. It was found by the officers of the Ordnance survey, and by Mr. SIMMS when repeating the operation, that the hypothesis of equal expansions of metals for equal increments of temperature, as shewn by the mercurial thermometer, is far from exact. Mr. BAILY's preliminary measures also shewed that the differences between certain standards had varied sensibly since the time when he constructed the standard scale of the Society. The method of properly supporting a bar has been recently considered by the Astronomer Royal, in a paper contained in our newly published volume. This is not a proper place or time for entering upon the details of processes which must be tried before they are approved of. The apparatus is well advanced, and the objects proposed are, to ascertain the best material for a measure, with the law of expansion of the material; to perpetuate the measure itself, although the material may undergo slow changes from molecular action; and to leave commencing data for a more complete inquiry into the subject, to be made in another generation. Mr. SHEEPSHANKS, up to this time, sees no reason to doubt of success, though in such delicate researches difficulties and anomalies are pretty sure to present themselves. So far as he is able he will tread in Mr. BAILY's steps, faithfully recording every thing as it presents itself, without

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hypothesis, and having recourse to every available source of information. The Fellows of this Society, well aware as they are of the perfect familiarity with every class of instrumental means which Mr. SHEEPSHANKS possesses, will look upon his labours as they proceed with no ordinary interest.

The circumstances relating to the discovery of the planet *Astræa* were detailed in the last number of the Society's *Monthly Notices*, and it will, therefore, be unnecessary to detain the meeting by any lengthened remarks on the subject. When the planet was first observed in this country it shone with the brilliancy of a star of between the ninth and tenth magnitudes. At the end of December a very material decrease in its brightness had occurred, and at the commencement of the present month the planet could hardly be reckoned brighter than the eleventh magnitude. There is a hazy, ill-defined appearance about *Astræa*, which makes it a matter of no great difficulty to distinguish her, even should there be several small stars in the field with her. Professor ENCKE was the first to calculate the elements of the new planet; his second elements were marvellously exact, though based on observations extending over thirteen days only. There is a very near agreement in the results of different astronomers, which shews that we have already closely approximated to the orbit of the planet.

In duly acknowledging the service rendered to astronomy by this discovery, we must not forget that we owe much to the exertions of Professor ENCKE, who detected the planet again on the 14th of December, and observed it very carefully at every opportunity. On these observations is based M. D'ARREST'S excellent Ephemeris, which has been of great assistance to astronomers during the past month.

Since the last Anniversary of the Society three comets have been discovered, and the periodical comets of ENCKE and BIELA have returned agreeably to prediction.

Father DE VICO, director of the Observatory at Rome, and one of the Associates of the Society, detected a telescopic comet on the night of February 26, 1845. It did not become visible to the naked eye, and was not observed after the end of April.

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At the beginning of June a fine comet made its appearance in the constellation *Perseus*. It was followed by astronomers until the end of the month, when it was lost in the twilight. There is strong evidence in favour of the identity of this comet with that of 1596, observed by TYCHO BRAHÉ; an elliptical orbit of 249 years' period satisfies the observations very well. Father DE VICO saw ENCKE's comet on two days in the month of July, but it does not appear that other astronomers were so fortunate.

The comet of BIELA was found at Berlin with the great FRAUNHOFER refractor on Nov. 29, and at Cambridge, by Professor CHALLIS, on Dec. 1. At this time it was excessively faint, but the agreement between the observed places and the positions given by SANTINI's elements is very satisfactory. In the middle of last month the comet became double, and presented a most singular appearance, for the nebulosities surrounding the two nuclei scarcely joined each other, and the whole object exactly resembled two comets in very close proximity. This phenomenon was first observed by Professor CHALLIS, with the Northumberland telescope, on Jan. 15. It was, however, seen in America, on the 13th. As viewed in Mr. BISHOP's refractor on Jan. 24, the comet was much like the *dumb-bell* nebula in *Vulpecula* seen under small optical power. The distance between the two comets has been since rapidly increasing, and the deviations of the positions of both comets from those deduced from SANTINI's Elements are now very great.

On the 24th of January last, Father DE VICO discovered a telescopic comet in *Eridanus;* this is the third comet detected by our indefatigable Associate. On the subject of comets the Council received a letter from our distinguished Associate, Professor SCHUMACHER, dated May 5, requesting that the observations made in England might be immediately forwarded to him, and promising a like return. The Council accordingly directed that all observations which came into their hands should be immediately sent to Mr. SCHUMACHER; and they hope that those Fellows who observe comets will lose no time in communicating their observations through Mr. HIND, who has undertaken to forward them to Professor SCHUMACHER.

The return of Mr. PIAZZI SMYTH to Europe enables the Council to furnish the meeting with a short account of Mr. MACLEAR's geodetical operations.

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The anomalies known to exist in LACAILLE's southern arc, and which Colonel EVEREST, when he visited the scene of operation, suspected to have arisen from local attraction on the plumb-line, have been the means of leading Mr. MACLEAR into a very extensive measurement of the same kind, of which, in such a Report as the present, we can only give a passing notice. When, in 1837, LACAILLE's Observatory at his southern end was trigonometrically connected with the Royal Cape Observatory, there was found to be error in the latitude of the former, certainly of the kind which the local attractions would cause, but by no means sufficient in amount to explain all the difference between the theoretical and the measured degree. But even this partial explanation was destroyed by Mr. MACLEAR's subsequent measures with the zenith sector at both ends of LACAILLE's arc, which produced results agreeing (as to the length in the heavens of that arc) almost exactly with that of LACAILLE. The discordance being thus thrown upon the trigonometrical part of the operation, Mr. MACLEAR (1840–41) carefully measured a base of 42,000 feet nearly on the site of LACAILLE's, and then re-observed all his triangles, feeling confident that the former stations had been recovered in every instance to within a few feet. The length of the degree thus found halved the difference between LACAILLE and the modern state of the theory, being about 200 feet less than that of the former, and about as much more than that of the latter. But, the old triangles being but ill chosen for causing errors of observation to produce their least effects, Mr. MACLEAR took another and a more advantageously related system, and found a result agreeing almost exactly with his former one. Still the effect of attraction at the southern end only remained imperfectly compensated, and that at the northern not at all. Mr. MACLEAR then resolved to extend the arc to the length of the usual European ones, to place the terminal stations in the best positions which could be found, to swing the pendulum on every mountain, and to fix the positions of all such points as might be useful in future land or coast surveys. This work has occupied him during the course of the years from 1843 to the present time, and it is not yet completed. Either of four stations may be used independently at the extreme southern end of the arc — the Royal Observatory, LACAILLE's Observatory in Cape Town, one on the mountain Zwarte Kop, twenty miles south of the observatory, and one on Cape Point, the extreme south-west of Africa. The most northern station is on the Khamiesberg, giving a total length of about

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4½ degrees, with an intermediate astronomical station on the top of Heer Logiments-berg. From the extreme south to the middle station two sets of triangles are formed; from thence to the northern, one and a part of another. From the Royal Observatory extends an eastern chain of triangles, for the settlement of the position of Cape l'Aguillhas and the measurement of an arc of parallel. The sides of the triangles vary from 50 to 90 miles. The country to the north of Khamiesberg is now under examination, to try the feasibility of carrying the triangulation up to a station at which a perfectly unexceptionable latitude can be obtained. The physical difficulties of the northern part of the triangulation have been enormous: the houses at 20 miles' distance from each other: the natives themselves imperfectly, and sometimes not at all, acquainted with the mountains through which the surveyors had to explore difficult passes in most inclement weather — the difficulty of finding water, and the scanty quantity of it when found — the irksomeness and danger of carrying the instruments up ascents which a free and active man can only surmount with difficulty — the endurance of all temperatures, from sand in the plains at 140° of Fahrenheit to ice and sleet on the heights — and the possibility of return being cut off by the gathering of snow in the ravines, — present a picture far from inviting, and form a measure of the resolution of Mr. MACLEAR and his assistants, as well as of the strength of the principle which carried them into those wilds. The Society will join the Council in hoping that their success may be equal to their desert.

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AN ADDRESS

DELIVERED AT

THE ANNUAL GENERAL MEETING

OF

THE ROYAL ASTRONOMICAL SOCIETY,

FEBRUARY 13, 1846,

ON PRESENTING THE HONORARY MEDAL

TO

G. B. AIRY, ESQ. M.A. F.R.S. ASTRONOMER ROYAL,

BY

CAPTAIN W. H. SMYTH, R.N. K.S.F. D.C.L. F.R.S. ETC.

AND PRESIDENT OF THE SOCIETY.

THE Report, Gentlemen, which you have just heard, has acquainted you that your Council have awarded the Medal of this Society to Mr. AIRY, the energetic Astronomer Royal, for his reductions of the Planetary Observations made at Greenwich between the years 1750 and 1830, by which an immense magazine of dormant facts contained in the annals of the Royal Observatory are rendered available to astronomical use. It may be proper, in expressing the grounds of this adjudication, to allude to the extensive nature and elevated character of that extraordinary work, as well as to the peculiar incidents connected with its production, which have brought it within the recognition of your Council.

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It is, of course, understood, and has always been acted upon, that work, however excellent and useful, does not enter into competition when it only follows the necessary duty of the author. Our medal was primarily instituted as a mark of approbation on individual exertion, on labours of love; and not to note our sense of the official merits of public men, or of the rectitude and ability with which they may acquit themselves in their respective offices. Now the weighty reductions in question come before us as executed at the expense of her Majesty's Government by the Astronomer Royal. It remains, however, to be added, that the undertaking was proposed by that distinguished individual long before his appointment to Greenwich. After his attention had been particularly called to the planetary theory, by his taking charge of the Cambridge Observatory,—having already investigated the errors of the Solar Tables and the long inequality due to *Venus*,—he saw the immediate necessity of a complete computation of all the older *exact* observations, which is nearly equivalent to saying of those made at Greenwich since the erection of the new transit instrument by Bradley in September 1750, and no others. The importance of this object does not seem to have struck the authorities on Mr. Airy's first proposal; but after the British Association was formed, a deputation of that body waited upon the Chancellor of the Exchequer in 1833, and obtained his consent to defray the necessary expenses. Mr. Airy's offer was, that if the Government would meet the cost of reduction and printing, he would undertake the entire preparation and supervision of the work gratuitously; so that he undeniably has the merit of originating, pressing, carrying the proposal into successful operation, and bringing it to a most satisfactory conclusion, almost solely and exclusively, and without any pecuniary advantage or official call. The publication of the reductions was ordered by the Lords Commissioners of the Admiralty, in consequence of a recommendation made to them by the Board of Visitors of the Royal Observatory of Greenwich, on the 25th of June, 1841.

This is the real origin of the reductions, and we find displayed in the execution of the task qualities of a higher order than that mere zealous and patient perseverance so often consumed in the mechanical department of computation. For, raised as he was by his own talents and application to an almost unrivalled height over the field of astronomy, Mr. Airy was not only able to take in at one view the actual existing state of the science, but could

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also look back and trace all the wanderings of former inquirers, each proceeding in his own narrow foot-path according to his own peculiar views of the various constants of refraction, nutation, aberration, and other elements of reduction. Through this wilderness he cut a broad highway, connecting all those separate labours, and making each of them serviceable to the common end; as when a drain is cut through a marshy soil, and the waters of numberless useless pools are collected and led into one straight channel, which carries the improver through the before impracticable region, ready to apply his whole energy on the space beyond. But although much of this may be said of the Greenwich documents, still the original observations were so fairly and fully stated, and are so completely preserved, that they now admit of reduction with the same exactness as at the time when they were made. Still it is by no means a simple task to make one's self conversant, not only with the merits, but with all the peculiarities, the weaknesses, and failings of both instruments and observers for a period of eighty years, as the Astronomer Royal has done.

The contents of this precious work are comprised in a quarto volume of above 700 pages, excellently printed, and divided into five sections. The first is devoted to the ascertaining of the clock errors, comprising the intervals of the wires, corrections for imperfect transits, and the position of the instrument, the effects of personal equation, and the rules by which the fundamental and determining stars were chosen; the second section contains the investigation of index errors and zenith points of the mural quadrants and circles; the third exhibits the computation of the geocentric places of the planets, as deduced from actual observations; the fourth shews the computation of the geocentric places of the planets, from the best existing tables of each of the bodies; and the fifth section gives the comparison of the observed with the tabular places, and expressions for the discordances in terms of the heliocentric errors of the earth and planets. These sections are briefly yet luminously described in an introduction of only thirty-four pages: but, though short, it would be difficult to name another specimen of astronomical writing of equal clearness and excellence. There are then twenty pages of the errata detected, either in the published volumes of the Greenwich Observations, or in the fundamental tables on which the planetary computations are founded; and the book concludes with nineteen skeleton forms of the schemes employed in reducing

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the matter. The whole is so lucidly and methodically arranged, that any one with a very moderate amount of elementary knowledge can take up an observation and conduct the process to the end; for he will be able to check every important step in the result by a reference to the volume itself, to the formulæ, and to the skeleton forms.

But if I may venture to express my opinion on this point, I would add, that it is very improbable that a casual examination of the steps of the processes should produce any useful result beyond that of gratifying a laudable curiosity, or familiarising the student with calculations and investigations of this kind. In all cases of doubt, the original documents have been consulted, and every effort which great experience and singular acuteness could suggest, has been made to clear up such mistakes as will always be found in large masses of observations. The mode of exhibiting the results is a great safeguard against errors of computation, and in passing through the press every portion of the work has been subjected to a most scrupulous revisal. The advantages of accuracy need not be insisted upon here, and I feel confident that the present book approaches in this respect as near to perfection as, humanly speaking, that limit can be attained.

Such is the work which your Council have considered it their duty thus to appreciate. The masses of results obtained by this operose application of thought and labour may be likened to the extraction of ore from the dross of an ancient furnace; and I am gratified in having already had the satisfaction of publicly expressing my high sense of the vast importance of the task. Every stage of the undertaking has stamped the Astronomer Royal as being fully in command of the whole process; and in exhibiting the rare union of large conception, profound learning, and pains-taking practice, proves him worthy of being the leader of the astronomical establishments of the kingdom. From the well-directed exertion of such talents the scientific world now reaps the benefit of the enormous calculations before us, the whole utility of which cannot yet, probably, be specifically stated. But we know, that whatever improvement may be made in the theory or constants of any one of the planets, or of the earth, the effect will be shewn in its corresponding influence on the heliocentric places of the earth and planet. Now, the equations which connect the variations of these elements with errors found by observation are

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all tabulated and grouped ready for the geometer's use, without requiring him to look beyond the fifth section, and with a degree of precision which no single computer could ever hope to arrive at. And as in botany we assume a new era from the time when Linnæus reduced the disjointed facts and instances of his day into a methodical system, by which men were able to make themselves masters of every truth which had been discovered up to that period, and turn their attention to something certainly new and useful; so may we, perhaps, date a new epoch in planetary astronomy from the appearance of the great work before you, since the desiderata in this department of the science are rendered visible, and the necessity for exact instants, a greater refinement of methods, and more delicate observations made apparent.

The President then, delivering the Medal to Mr. Airy, addressed him in the following terms:—

Mr. Airy,—I have great pleasure in presenting to you the Medal which has been so justly awarded by the Council, in recognition of your admirable zeal, ability, and judgment, in carrying out the reductions of the Planetary Observations. And be assured of our earnest hope, that a long and happy life may enable you still to achieve successive astronomical triumphs.

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REPORT OF THE COUNCIL OF THE SOCIETY

TO THE

TWENTY-SEVENTH ANNUAL GENERAL MEETING,

FEBRUARY 12, 1847.

THE Council cannot commence this Report of the twenty-seventh year of the existence of the Society without a strong expression of congratulation for the present, and of hope for the future. The state of astronomy, both at home and abroad, is one of decided progress, and of progress which promises to continue.

Both theory and observation, singly and united, are cultivated with signal success. Of the prospects of our own Society in particular, the Council are able to speak as usual, in terms of hope and encouragement.

The Report of the Auditors, subjoined, will shew the state of the finances:—

Receipts.

	£.	s.	d.
Balance of last year's account ..	256	5	9
1 year's dividend on £900 Consols	26	4	4
1 ditto on £2228 1*s.* 7*d.* New 3¼ per Cents	70	6	0
On account of arrears of contributions	73	10	0
Carried forward ..	£426	6	1

Expenditure.

	£.	s.	d.
Cash paid for Investment of 1 composition	21	0	0
Magnay and Co. for paper	23	2	6
Mr. Harrison, for stationery	13	16	8
Executor of R. Harris, for comet computations	30	0	0
Carried forward ..	£87	19	2

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Receipts.

	£	s.	d.
Brought forward....	426	6	1
74 contributions (1846–47)	155	8	0
4 ditto (1847–48)	8	8	0
3 compositions	61	19	0
3 admission fees.....	6	6	0
1 first year's contribution	2	2	0
Sale of Memoirs.....	60	15	0
	£721	4	1

Expenditure.

	£	s.	d.
Brought forward....	87	19	2
Mr. Barclay, for printing Memoirs	187	16	0
Mr. Barclay, for printing Monthly Notices, &c.	50	18	6
Mr. Vickery, for law expenses ..	5	5	0
Taxes: Land tax and window duty, 4 qrs. 8 7 2; Income and property tax, 8 quarters .. 2 18 4	11	5	6
Mrs. Harris	25	0	0
Ditto and J. Williams, commission on collecting £326 8s.	16	6	2
J. Williams, for 3 quarters' salary as Assistant-Secretary	75	0	0
Charges on books, and carriage of parcels	4	13	6
Postage of letters	17	8	11
Porter's and charwoman's work, &c.....	11	4	8
Tea, sugar, cakes, &c. for evening meetings.....	13	12	0
Coals, candles, &c.....	12	18	6
Sundry disbursements by the Treasurer	13	15	11
Balance in the hands of the Treasurer (January 23, 1847).	188	0	3
	£721	4	1

The assets and present property of the Society are as follow:

Balance in the hands of the Treasurer				£188	0 3
Arrears, Jan. 28, 1847.	3 contributions of 8 years' standing	£50	8 0		
	3 ——— of 7 ditto	44	2 0		
	4 ——— of 6 ditto	50	8 0		
	1 ——— of 5 ditto	10	10 0		
	1 ——— of 4 ditto	8	8 0		
	9 ——— of 3 ditto	56	14 0		
	10 ——— of 2 ditto	42	0 0		
	12 ——— of 1 ditto	25	4 0		
				287	14 0

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£900 3 per Cent Consols.
£2249 1*s.* 7*d.* New 3¼ per Cent Annuities.

Unsold Memoirs of the Society.
Various astronomical instruments, books, prints, &c.

The progress and present state of the Society, with respect to Fellows and Associates, is as follows, continued from the Report of last year :—

	Compounders.	Annual Contributors.	Non-residents.	Patronesses, and Honorary.	Total Fellows.	Associates.	Grand Total.
February 1846..	121	128	74	5	328	37	365
Since elected...	4	5	..	..	9	1	10
Deceased.....	−1	−4	..	..	−5	−1	−6
Resigned.....	−1	−3	..	..	−4	..	−4
Removals.....	..	+1	−1	..	..	..	..
February 1847..	123	127	73	5	328	37	365

The instruments belonging to the Society are now distributed as follows :—

The *Harrison* clock,
The *Owen* portable circle,
The *Owen* portable quadruple sextant,
The *Beaufoy* circle,
The *Beaufoy* transit,
The *Beaufoy* clock,
The *Herschelian* 7-foot reflector,
The *Greig* universal instrument,
The *Smeaton* equatoreal,
The *Cavendish* apparatus,
The Universal quadrant by Abraham Sharp,
The 7-foot *Gregorian* reflecting telescope (late Mr. Shearman's),

are in the apartments of the Society.

The brass quadrant, said to have been *Lacaille's*,

is in the apartments of the Royal Society.

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The Standard scale

is in the charge of the Astronomer Royal, with the consent of the Council, to be used in the formation of a new standard measure, under the direction of the Standard Committee.

The *Lee* circle

is now in the hands of Mr. SIMMS for some repairs, preparatory to its being returned by Lord WROTTESLEY.

The remaining instruments are lent, during the pleasure of the Society, to the several parties undermentioned, viz.:

The *Fuller* theodolite, to the Lords of the Admiralty.
The other *Beaufoy* clock, } to the Royal Society.
The two invariable pendulums, }
The Wollaston telescope, to Professor SCHUMACHER.
The Variation transit (late Mr. SHEARMAN's), to Mr. J. REES.

The sixteenth volume of the *Memoirs* of the Society is now in the press, and as twenty-two sheets are printed, it is confidently expected that its publication will not be delayed beyond the end of March or the beginning of April next.

Among the presents which have been received during the last year are three which merit particular notice.

First, a box of papers was transmitted to the Society on the 18th of last July, by the sister of our late President, FRANCIS BAILY. This box contains (besides stocks of skeleton forms) proofs and computations connected with the reduction of FOSTER's pendulum observations, the standard scale, catalogue of stars, &c. Though Mr. BAILY was, of all men, the one whose manuscripts were least wanted after their publication, owing to the great care with which his proofs were revised, yet it must be satisfactory to have the means of reference to original documents, even in his case.

Secondly, SIR THOMAS BRISBANE has presented the manuscript of the transit and circle observations, made at Paramatta in 1823–1826, with some copies by Mr. RUMKER of part of the series made in former years.

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Thirdly, Mr. WILLIAM WILSON, the senior member of the Mathematical Society, presented, in June last, twenty-five engraved portraits of astronomers, having among them thirteen different portraits of NEWTON. NOBLE, in his continuation of GRANGER, describes but twenty-three engravings of NEWTON. With such a beginning, there may be reason to hope that the Society will be able to complete its set of the tributes of this kind which have been paid to the first of modern philosophers.

The vacancy in the situation of Assistant-Secretary, caused by the lamented death of Mr. HARRIS, has been filled up by the appointment, on the 8th of April last, of Mr. JOHN WILLIAMS, a Fellow of the Society, one of the gentlemen incorporated from the Mathematical Society, as described in the last Annual Report. It was, of course, judged expedient that Mr. WILLIAMS should cease to be a Fellow of the Society from the date of his appointment, and during his tenure of this office. The selection was made on the usual grounds of superior fitness; and though it was hardly, if at all, thought of at the time, yet it turns out that the perfect command of the Mathematical Society's Library, obtained by several years management of it, renders Mr. WILLIAMS's services in the formation of the Catalogue of much more importance than those of any new Assistant-Secretary could have been expected to have been.

The Society will receive with satisfaction the information that Sir JOHN HERSCHEL has allowed himself again to be put in nomination for the office of President. The printing of his great work on the southern stars is now more than four-fifths completed, and its speedy appearance may be expected. The reduction and correction of the press, though none can do it effectively except the author and observer, is not the occupation which an inventive mind would choose: and science is under great, and frequently unacknowledged, obligations to those who take the pains to render their more pleasant labours effective by the performance of the drudgery which they entail.

The Society loses the valuable services of Mr. RUTHERFORD and Mr. SHEEPSHANKS as Secretaries; but the latter gentleman continues to take charge of the *Monthly Notices* for the present.

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The Catalogue of the Library is in a state of forwardness: the slips from which it is to be printed being written out and arranged in alphabetical order.

The books of the former Mathematical Society, alluded to in the last Annual Report, prove to be a very valuable addition. Very few sets, indeed, are imperfect, and many volumes are of an unusual, some of a rare, character. It must be added that no two collections of books could be more different in character than that of the Mathematical Society and that with which it has been incorporated: the former being mostly mathematics and chemistry of the seventeenth and eighteenth centuries, and the latter astronomy of the eighteenth and nineteenth centuries. Accordingly, the duplicates, which have been created by the incorporation of the two, are fewer in number than usually happens when two professedly scientific libraries are united. In the printed catalogue, the books of the Mathematical Society will be distinguished by a peculiar mark; and the rest, forming our own library, will have the names of the donors attached or otherwise signified.

The Council hope that, when the Catalogue is published, the Society may count upon the assistance of the Fellows in completing such sets of books as are deficient. The information where a casual copy of a missing volume can be obtained, will always be most thankfully received by the Assistant-Secretary.

We have to regret, on our home list, the deaths of Dr. Bostock, Sir Nicholas Tindal, Capt. J. F. Egerton, Mr. John Glaisher, and Mr. Rowbotham; and, on the foreign list, of our celebrated associate Bessel, and of Baron Damoiseau.

Dr. Bostock was born in 1774, and died on the 6th of last August. He was for nineteen years an active medical practitioner in his native town of Liverpool; but he gave up his profession in 1817, and settled in London, where, till his death, he was actively engaged in the promotion of science. As he paid no special attention to astronomy, he was, though a Fellow of this Society, not a frequent attendant at our meetings. The Royal Society engrossed much of his attention; and an account of his scientific labours will be found in the last Annual Address of the President to that body. But,

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though not much among us in this room, Dr. BOSTOCK was well known and highly respected by a large number of our Fellows, not less for his private worth than for his numerous and useful labours. Amidst many public engagements in scientific societies and medical charities, he found time to contribute sixty-nine communications, many of them requiring much research and labour, to journals, transactions, and cyclopædias. Most of these relate to his profession of medicine, which he never deserted, though abandoning what is usually called its practice. As a lecturer, a writer, or a manager of an hospital, he was to the last engaged in the promotion of medical science.

Sir NICHOLAS CONYNGHAM TINDAL was born in 1776, at Chelmsford. His education was commenced at the grammar-school in that town, and continued at Stoke-by-Nayland under the Rev. Mr. PARLBY. He was articled to his father, Mr. ROBERT TINDAL, an attorney at Chelmsford; but after a year's service he entered, with his father's consent, in 1795, at Trinity College, Cambridge. In 1799 he took his bachelor's degree, being eighth wrangler and senior medallist. In 1801 he gained the second member's prize, and was elected fellow of his college.

Having selected the law as his profession, he entered himself of Lincoln's Inn and studied pleading, first, under Mr. SERJEANT, and then under Mr. BAYLEY (afterwards Mr. Justice and Baron BAYLEY). He pleaded under the bar till 1809, the year of his marriage; he was then called, and went the northern circuit.

A learned argument in the famous case of Wager by Battle established his reputation as a lawyer; and his conduct on the Queen's trial drew upon him the marked attention of Lord LIVERPOOL. He sat for the first time in Parliament as member for the South Scotch Burghs, in 1824, when he was appointed Solicitor-General. In 1826 he sat for Harwich, and in 1827 he succeeded Lord LYNDHURST as member for the University of Cambridge. In 1829 he was made Lord Chief Justice of the Common Pleas, which office he held at the time of his death, on July 6, 1846.

It could not be expected that one so deeply occupied in an engrossing profession would devote much time to astronomical science. But Sir NICHOLAS

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TINDAL never lost his interest for his earlier studies, and his familiarity with classical literature never abated. We are told that he attentively read over the mathematical papers which are annually prepared for the Cambridge examination; and when on the circuit he not unfrequently spent a leisure hour in Captain SMYTH's Observatory at Bedford.

To Sir NICHOLAS TINDAL's domestic virtues and his legal attainments, those best qualified to form an opinion have given the strongest testimony. In public estimation he "truly and indifferently administered" the law he was sworn to observe "without fear, favour, or affection:" in this cardinal quality he has not been surpassed by any one of those upright judges who have adorned the English bench.

Captain JOHN FRANCIS EGERTON, of the Bengal Artillery, third son of Sir PHILIP GREY EGERTON, died on the 23d January, 1846, of wounds received on the 22d December preceding, in the severe and prolonged battle of Ferozeshur. He was attached, as assistant quarter-master-general, to the division of Sir JOHN LITTLER, who occupied Ferozepore before the commencement of hostilities. On the report of an attack upon our territories, Captain EGERTON was sent, on December 11, to reconnoitre. Leaving his escort behind, he proceeded with two orderlies until he was saluted by a heavy fire from the invading Sikhs. This was the opening of the campaign.

Sir J. LITTLER, in his despatch, after the battle, says:—"Of Captain EGERTON, my assistant quarter-master-general, whose zeal and activity were conspicuous, I cannot speak too highly; he was severely wounded on the morning of December 22." In a private account he is said to have been discovered "almost cut to pieces."

Mr. JOHN GLAISHER was born in March 1819, and died May 16, 1846. When he left school at the age of fourteen, he resided with his brother, Mr. JAMES GLAISHER, then Assistant at Cambridge Observatory. He soon began to observe, and attained skill in the use of the instruments: he also acquired a practical knowledge of the reduction of observations. From 1834 to 1845, he was employed by Mr. AIRY in the Greenwich planetary reductions: in February 1836, he succeeded his brother as Assistant at Cambridge, on the

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removal of the former to Greenwich. He left Cambridge in the beginning of 1845, and became Astronomical Assistant to the Rev. J. B. READE, of Stone, and to Dr. LEE, at Hartwell. In July 1845, he sustained a shock, from which he never recovered, in the death of his wife, three weeks after their marriage. During his employment at Cambridge, he made most of the circle observations, and was conversant with the other instruments. Mr. CHALLIS says, "In all the instruments he was equally skilled. He computed rapidly and correctly; and in all respects was to me a most valuable assistant."

Mr. JOHN ROWBOTHAM was born September 5, 1793, at Elston Mill, near Newark, in Nottinghamshire. This mill, by which his father earned his livelihood, was a freehold, which had descended from father to son from the time of CHARLES II. After a school education, he was employed under his father, at the age of fifteen, and was soon allowed to understand the business better than any one in the neighbourhood. Two years afterwards, having saved a little money, which he earned by surveying for the farmers in the neighbourhood, he resolved to try his fortune in London. He failed, and was obliged to return; but, in one more year, having been employed as clerk and overlooker in a larger mill, he had again saved a little stock, and resolved to try once more. He was employed as assistant to GEORGE CRABB, known as the author of several works on education and on teaching German; and afterwards was his partner and successor in his school, which was at Walworth. Mr. ROWBOTHAM had a turn for acquiring languages; his knowledge of which he first began to extend beyond his foundation of school Latin and Greek, by playing at dominos with the French emigrants in the coffeehouses which they frequented. He procured a knowledge of French, German, Italian, Spanish, Dutch, and Danish, besides a little Chinese; on some of these languages he wrote grammars or other elementary works. With an early turn for mathematics (a taste seldom combined with that for languages), he cultivated the elements of that science with success, and his name is associated with that of Mr. PETER NICHOLSON in the later editions of the work on algebra, published by the latter. Mr. ROWBOTHAM's useful and laborious life terminated on the 16th of October last, at Walworth. He had long been a Fellow of this Society, and was a regular attendant at our meetings. His elementary works are numerous; they are carefully done,

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and have had much circulation. Perhaps no Englishman of his day has written so many helps to foreign languages.

Among the losses which the Astronomical Society have to deplore by death among its members in the year elapsed, is that of our illustrious associate, BESSEL, a name for ever memorable in the history of our science as that of one who, independent of great and distinct discoveries, by which he enlarged its bounds, may be said to have impressed on it a new aspect in almost all its details, and to have contributed more than any preceding astronomer to give to all its processes of calculation, and to many of those of observation, that refinement and systematic perfection which now so pre-eminently distinguish them. This is, perhaps, the more remarkable, as he was, in the most especial sense of the word, a self-taught astronomer; but, unlike self-taught men in general, whose characteristic is for the most part that of rude energy and native strength rushing upon its object, and satisfied with its attainment, his genius, assimilating every new acquisition to a model of ideal symmetry and completeness in his own mind, embodied it at once in its neatest and most finished form, and in that which offers the easiest handle for subsequent application.

FRIEDRICH WILHELM BESSEL was born at Minden, July 22, 1784. His father held an office of local administration under the Prussian government (Justiz-Rath). His mother was the daughter of a clergyman, SCHRADER by name, at Rehme. Being one of a family of nine children, his education, though not neglected, was in no respect calculated to fit him for his future distinguished career. It is said that he shewed an early disinclination for the elements of classical literature; most probably from the repulsive form in which they are usually administered to children. Be that as it may, he manifested a decided preference for, and early expertness in, arithmetic; which his father perceiving, placed him, at the age of fifteen, as an apprenticed clerk in a considerable commercial house at Bremen (KUHLENKAMP and Sons).

A boyish story is told of his grinding a glass with emery in a saucer, and remarking, with delight, that it in some degree concentrated the rays of the sun; perhaps in rude imitation of some process he had read of, or been told. A more decidedly characteristic anecdote is recorded of his having, in his

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thirteenth year, remarked, while comparing the constellations in the heavens with their representation on a planisphere, that ε *Lyræ*, marked as one star in the chart, consists of two, which his eye was sharp enough to distinguish separately, though at so small an interval as 3′ 32″. This must certainly be regarded as an uncommon proof, not only of acute vision, but of close and careful attention in a boy so young, and as manifesting that capacity for becoming earnestly interested in a subject to which the natural faculties of the mind are best adapted, which is all that can be understood by an early bent of genius.

Earnest attention and zealous occupation with the business before him, of whatever nature, seems, however, to have been a primary feature of his character. In his new situation, he speedily mastered, not merely the routine of his own subordinate position, but gained a thorough insight into the general nature of the business of his firm; and, entering into all his duties with uncommon diligence, rapidly acquired the approbation and confidence of his employers; leading them to hope that the more responsible situation of supercargo, in a voyage to the French and Spanish colonies and China, might be offered to him. To prepare himself for this great object of his ambition, he commenced the study of the French and Spanish languages, and of navigation, taking for his guide in that branch the old work of Hamilton Moore. The rules and processes of nautical reckoning delivered in that work as precepts, without their theoretical grounds, induced him to seek the latter elsewhere. He procured a popular treatise on astronomy. This directed him in the right course; and, proceeding from book to book, and mastering their difficulties as best he might, he found at length an effectual bar to further progress in his entire unacquaintance with mathematics. He immediately entered on a course of mathematical reading, and now we hear no more of commercial projects, or of the voyage he had so ardently desired. Every leisure hour (and they were chiefly in the night) was devoted to astronomical and mathematical reading. Practice was also combined with theory. By the aid of a rude wooden sextant, which he got constructed by a carpenter, and a common clock, he began to make observations for time; and great was his joy when the occultation of a considerable star by the moon, which he was fortunate enough to observe, gave him the longitude of Bremen with considerable approximation. The rapidity of his progress from this time

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was truly astonishing. Trains of original research and learned inquiry opened out before him at an age when the generality of students, under the most favourable circumstances, hardly advance beyond the elements of science. Already in his twentieth year, he had executed the reduction of HARRIOTT's and TORPORLEY's observations of the comet of 1607, which has become so celebrated by the great discovery of its periodical return by HALLEY. These observations had been but recently rescued from oblivion by Baron ZACH, in his search among HARRIOTT's papers, in the possession of the Earl of EGREMONT; and, being the first observations of this remarkable body made with any kind of instrumental aid, their reduction was an object of undeniable importance. This task BESSEL executed in so masterly a manner, as to call forth the warmest eulogies from OLBERS, to whom he communicated them, and to excite the strongest desire in him to secure for astronomy one whose future eminence in that science he clearly foresaw, and in no sparing or measured terms predicted. This performance, his first published work, appeared in ZACH's *Monathliche Correspondenz,* and was immediately followed by a theoretical memoir, of great merit, "On the calculation of the true anomaly in orbits nearly parabolic." So expert had he become in cometic calculations, that OLBERS, having placed in his hands, on the night of the 1st of November, 1805, four observations of the comet of that year, he returned them to him the next morning, with the elements, whose calculation had occupied him only four hours.

His seven years' engagement with Messrs. KUHLENKAMP was now terminated; but, instead of entering on the mercantile world on his own account, we find him placed forthwith, at the recommendation of OLBERS, as assistant to SCHRÖTER, at Lilienthal, and successor to HARDING. Astronomy thus became his profession; he gave himself wholly to it, with an energy and success which very speedily placed him in the first rank of its cultivators.

The instruments of SCHRÖTER were better adapted for physical examination than for precise astronomical determinations. Among the more especial objects to which his attention *as an observer* was there directed, may be mentioned a series of micrometrical measures of the distances of the sixth, or Huyghenian, satellite of *Saturn* from the ring, made with a Newtonian reflector by the aid of the projection micrometer, with a view to the better

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determination of the mass of *Saturn* and of its ring, by means of the perturbations caused thereby in the satellite's motions. This work, so began, was never subsequently lost sight of. It forms the subject of several elaborate memoirs, the first of which appeared in the *Königsberger Archiv fur Naturwissenschaften*, No. 2, in which all the observed conjunctions and oppositions of the satellite, and all the recorded disappearances of the ring, are subjected to a rigorous and systematic calculation; the position of the ring itself normally determined, together with elements of the orbit of the satellite in question, and even the perturbations of its motion by the attraction of the ring and by the sun are made objects of minute inquiry. The subject was resumed as observations accumulated, especially those made with the celebrated heliometer of FRAUNHOFER, in three admirable papers, Nos. 193–5, No. 214, and No. 242 of the *Astronomische Nachrichten*. At Lilienthal, also, were made his observations of the comet of 1807, the investigation of whose elements, taking into account its perturbations, was published in 1810, and gained him the prize founded by LALANDE, from the Institute of Paris.

In 1810, he removed from Lilienthal to Königsberg, being appointed to the direction of the observatory about to be established there by the King of Prussia, and whose construction and provision with instruments he was called on to superintend. This observatory will ever remain a monument to his glory, no less than to the munificence of the sovereign who, amidst the alarms of war and the desolation of his country, still mindful of science, ordained its institution. The building was completed and the observations commenced in 1813, from which time to the conclusion of his life an uninterrupted series of the most valuable and important observations continued to emanate from it. Soon after his appointment to this situation (in which, besides the duties of an observer, he had also those of a professor in the Königsberg University to fulfil, by giving a course of lectures on astronomy and mathematics) he married the daughter of Professor HAGEN, by whom he had one son and two daughters. The death of the former, however, in 1841, a fine and talented young man, who already, at an early age, gave the promise of eminent distinction in astronomy, proved to him a most severe trial; which, however, he bore with resignation, taking refuge from his grief in increased exertions. These brought on, or at least exasperated, an

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internal complaint, arising, in the opinion of his physicians, afterwards verified on actual examination, from the abnormal and fungous growth of some intestinal organ, under which, after much protracted suffering, he at length succumbed, and expired on the 7th of March, 1846, in the 62d year of his age.

An extensive and minute account of the labours of this illustrious astronomer cannot be expected in a notice of this nature: all that can be done is to touch, and that briefly, on some of the principal among them.

Of his early and successful devotion to the improvement of our knowledge of comets something has been already said. This ever continued a favourite subject with him; and, in 1835, he had the great satisfaction to observe, with all the means which modern instruments afford, the wonderful phenomena of HALLEY's comet, the reduction of whose early observations (in preparation for this return of it to its perihelion) had signalised his first entry into his astronomical career. His observations of its physical appearance previous to its perihelion passage, and especially of the apparent oscillations to and fro of those singular jets of light from its head, which created so much astonishment among European observers, from day to day, and even from hour to hour, led him to conclude the inherence in the cometary matter of a polar or magnetic energy, and even to make (*Astronomische Nachrichten*, No. 310) the effect produced on a comet's orbit by the reaction of the matter of these jets, so projected forth from the nucleus into space, a subject of mathematical calculation. And it may not be irrelevant here to notice that other phenomena, of a totally different nature, exhibited by the same comet subsequent to its perihelion passage, as observed in the southern hemisphere, appear to authorise conclusions which, though not precisely identical with those of BESSEL, have yet so much in common with them, that the assumption of repulsive forces as a means of accounting for cometary phenomena must henceforward take its place among hypotheses which cannot be lightly rejected, but must come to be tested by the combined aid of rigorous mathematical deduction and increased refinement of observation.

In a note appended to one of the numbers of the *Astronomische Nachrichten* (No. 175), the following remarkable expression of SCHUMACHER

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occurs:—"One may almost assert that one exact and able calculator is capable of doing better service to astronomical science than two new observatories." It was in the capacity of such a calculator (taking the word in that enlarged and eminent sense in which the writer doubtless understood it,—a calculator thoroughly master of every resource of theory, and capable of bringing them all to bear on the subject of discussion) that BESSEL undertook and completed, while yet young as an astronomer, his great work, the *Fundamenta Astronomiæ*, a work which it is difficult for any astronomer, and least of all an English one, to speak of in measured terms. It affords the first example of the complete and thorough reduction of a great series of observations, grounded, in the first instance, on a rigorous investigation, from the observations themselves, of all the instrumental errors, and carried out on a uniform plan, neglecting no minutiæ which a refined analysis and a perfect system of computation could afford, and resulting in a model catalogue, such as (without disparagement to the far more extensive catalogue of PIAZZI, published four years antecedently) the world had not before imagined. As Englishmen, we cannot but be proud to have furnished from our national observatory, in the twelve years' work of a single British astronomer, that "one entire and perfect" mass of precious material, from which has been sculptured forth in so masterly a manner, and in all its classical proportions, the fair form of modern sidereal astronomy. Independent of the deduction of the places of the stars, of the instrumental reductions, and of the local data, the disquisitions which this work contains on the several uranographical corrections are, and ever must remain, models of delicate and powerful research, monographs of their respective subjects, embodying in a succinct and perspicuous point of view, so far as their complexity will admit, the totality of our knowledge of their theory brought into the most practical forms for application. In the reduction of these observations, however, his final improvement, which does away altogether with the necessity of using special tables for the several uranographical corrections, and for individual stars, and renders it practicable, by the calculation of a system of constants for each star, and an annual table common to all the stars, to provide for the reduction of all meridional observations, was not yet adopted. That capital step, which has so infinitely facilitated all subsequent reductions, was not made till somewhat later, and had nearly been anticipated by Mr. BAILY, who, on his part, and independently, had been occupied about the same time

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on a similar simplification.* In furtherance of the important object of facilitating the reduction of observations of the planets, as well as of the fixed stars, on a uniform system, he prepared and published, in 1830, his *Tabulæ Regiomontanæ*, a work of the greatest utility and influence on the practice of astronomers in this respect.

The principal instruments at first supplied to the Königsberg Observatory were two, a transit by DOLLOND, and a meridian circle by CARY. This last instrument, though not itself of a very high order of excellence, may be considered as having been rendered so by the masterly and elaborate investigation of its errors of division which BESSEL bestowed upon it. The complete investigation of instrumental error was a subject on which he was at every period remarkably scrupulous, and not without reason, as the dreadful consequences which have followed its neglect in more than one instance clearly demonstrate. In *his* opinion, the reputation of no artist, however distinguished, could be held to dispense with the most careful and searching scrutiny into the errors of his workmanship; or, with the most refined application, both of experience and theory, into the amount and laws of its flexure, whether of the telescope or limb, by its own weight in different positions. In fact, no astronomer has ever gone deeper into the theory of instruments, or exemplified that theory by more elaborate experimental inquiries. The finishing hand was put to a most remarkable memoir on the effects of flexure, but a very short time previous to his death, which has only just seen the light (see *Astronomische Nachrichten*, No. 577, *et seq.*), its publication having been directed in his will.

The improvement of CARLINI'S tables of the sun was the object and result of the first five years' observations with CARY'S circle and DOLLOND'S transit; though other objects of interest were not neglected, especially that of an exact determination of the places of those stars in which large proper motions had been remarked. But when, in the year 1820, the circle of CARY was replaced by the larger and more accurate meridian circle of REICHENBACH, a wider field of inquiry was opened out, and a task undertaken and completed

* See the Memoir of Mr. BAILY, *Mem. Ast. Soc.* vol. xv. p. 324, where, in line 7, for *precession* read *nutation*.

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of which astronomy is only now beginning to reap the fruits. This was no less than a determination of the places of all the stars, down to the ninth magnitude, in a zone of the heavens extending from 15° south to 45° north declination. Previous to entering upon this great work, however, the new instrument was subjected to the same, or a more severe and rigid scrutiny into the divisions of its circle, and the accurate adaptation of its parts (by the aid of a microscopical apparatus contrived and executed by PISTOR), which its predecessor had undergone. It sustained the ordeal to admiration. The zone observations were commenced on the 19th of August, 1821, and completed on the 21st of January, 1833, in 536 zones, comprehending upwards of 75,000 observations. The arrangement of the work, as printed in the Königsberg observations, is in the highest degree convenient for reference. Every zone is accompanied by a small table, by means of which the reduction of any one of the observed objects to a fixed epoch may be performed at once, and in the shortest possible time; so that the observations themselves, by the aid of an index to the zones, have nearly all the advantage of a catalogue, and that of a very high degree of precision. Their actual reduction and arrangement as a catalogue was commenced in 1830 by Professor WEISSE; but the promised work has not, we believe, yet appeared. BESSEL was assisted in the observation of these zones by M. ARGELANDER, who, since his removal to the direction of the observatory at Bonn, has continued them from the 45th to the 80th degree of north declination, the observations being very recently published in the first volume of the transactions of the Bonn Observatory, in 204 zones. It will be a matter of no small interest, when the elements of the new planets which have so recently been added to our list shall have become sufficiently known to admit of a retrospective ephemeris being calculated, to search the Königsberg zones for missing stars lying in their paths, and corresponding to former places of them. The detection of such will be of inestimable value in the correction of their elements and the theory of their perturbations.

Future astronomers will reap the rewards of this laborious work; but there was one subject of astronomical research, of a practical nature, which BESSEL was destined to commence and carry out to its completion, terminating in a discovery of first-rate importance, in the determination, beyond the reach of reasonable doubt or cavil, of the parallax of a fixed star. The

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star, 61 *Cygni*, pitched upon for his attack upon this difficult question, which had so long bid defiance to the attempts of astronomers, and which seemed destined constantly to afford fresh proofs of the imperfections of our instruments and the inadequacy of our methods, was one which combined, with distinct grounds of *à priori* probability in favour of its proximity to our system, peculiar advantages for the application of the mode of observation contemplated. The proper motion is remarkably large,—the greatest, with one exception, yet observed. This of itself affords some presumption of proximity. Another, less equivocal, is found in the fact, that it is demonstrably a binary double star, whose orbitual motion is remarkably rapid when compared with the apparent angular distance of its individuals, indicating a large angular dimension of the orbit mutually described about each other as seen from the earth. As regards its adaptation for micrometric observation, two minute stars, at the respective distances of 8′ and 12′ from the middle point of the pair, situated with respect to that point in positions differing by very nearly a right angle, permit no parallactic movement to take place without effecting a change of apparent distance from one or other of them; so that the maximum rapidity of change with respect to one shall correspond to the minimum and near evanescence of such change with respect to the other, a very important circumstantial character of the *reality* of any observed movement supposed to arise from parallax.

The only obstacle in the way of the detection of any minute parallactic motion, by means of these stars, consisted in the difficulty of measuring distances so large as 8′ or 12′ to the precision of a very small fraction of a second. Thanks to the perfect workmanship of the Munich opticians, this precision was rendered attainable by the heliometer constructed for the Königsberg Observatory, and there erected in 1829. The observations in question were made in the years 1837–1840; and their result, as is well known, has satisfied every astronomer of the reality of the parallax attributed by Bessel to this star, and of the near approximation to its true amount.

The discussion of these observations involved considerations of very great delicacy, chiefly turning on the effect of temperature on the focal distances and metallic mounting of the lenses, as well as on an infinity of minute considerations as to the effects of refraction, &c., and of instrumental errors

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on the measures of angles of such magnitude in various positions with respect to the vertical. Every thing of this nature has been made the subject of minute and careful inquiry in four very elaborate papers forming part of the first volume of a series of Essays (*Astronomische Untersuchungen*), of which we shall have further occasion to speak. The first of these enters in its fullest extent into the general theory and formulæ of an equatorially mounted heliometer. The second is devoted to a special application of this theory to the Königsberg instrument: among the remarkable features of this second memoir, deserves to be noticed a happy application of the general resolution, by continued fractions, of an equation of finite differences of the second order, to the expression of the course of a ray refracted through any combination of spherical surfaces. The third of these memoirs relates to the elimination of the influence of refraction; and the fourth to that of the several effects of precession, nutation, and aberration, from measures so taken, and from micrometric measures generally.

The exceeding precision of micrometric measurement of which the heliometer proved capable was also brought to bear upon other objects, such as the measurement of distances of the Huyghenian satellite of *Saturn* from the ring, and those of *Jupiter* from the limb of the planet, with a view to the more perfect determination of the masses of these planets. The results of the latter observations, as compared with their theory, and the improved tables of the motions of the satellites themselves, concluded from the whole inquiry, are to be found in the Ninth Essay, Vol. II. of the *Astronomische Untersuchungen*, already referred to.

In the year 1824, in a paper communicated to SCHUMACHER'S *Astronomische Nachrichten*, No. 49, BESSEL recalled the attention of astronomers to the great and peculiar advantages in the determination of latitudes, and of the declinations of such stars as pass near the zenith, offered by a mode of observation whose first idea seems to have been due to the celebrated RÖMER, viz. by the use of a transit instrument at right angles to the meridian, and therefore describing the prime-vertical. By the use of this method, the differences of declination of two stars passing near the zenith of any given place, or the change of declination of one and the same star at different times, comes to be measured upon a vastly increased scale by the interval of

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its two transits over the vertical, expressed in time. It is therefore independent of the errors of division of any circle, and, as BESSEL has also shewn, of a variety of other influential causes of error, and is especially adapted for those inquiries in which the zenith sector has been usually employed. A large instrument constructed upon this principle has been since erected in the Imperial Observatory at Pulkowa, with the express object of affording normal results as to the constants of aberration, nutation, &c., and the investigation of parallax; and from the terms in which the illustrious astronomer at the head of that establishment speaks of its performance, the views of M. BESSEL in recommending it for general adoption appear to be fully borne out.

Intent on fully providing the observatory under his direction with the most perfect instruments which art can execute, BESSEL obtained permission to order for that institution a new and improved meridian circle from the Brothers REPSOLD, of Hamburgh, with peculiar adaptations devised by himself for facilitating the handling, setting, and reading of the circle. On the reception of this instrument, which was erected in the observatory about the end of 1841, a mode of determining the nadir point proposed by BOHNENBERGER, by reflexion of the wires of the instrument itself in mercury, by which the instrument is made its own vertical collimator, was adapted and brought into constant use; a full account of which, and of the extreme precision so attained, will be found in Nos. 480 and 481 of the *Astronomische Nachrichten*. The possession of this admirable instrument enabled him to resume, with every advantage he could desire, an inquiry of the greatest importance, but at the same time of the utmost delicacy, which had long engaged his attention. The first suspicion of a want of perfect uniformity in the proper motions of certain fixed stars, among which *Sirius* and *Procyon* may be especially particularised, occurred to BESSEL in 1834. POND appears also, at an earlier period, to have become impressed with the same idea. The observations of declination made at Königsberg, previous to the erection of the REPSOLD circle (see *Astron. Nachr.* 422), had tended greatly to confirm this suspicion; but it was not until a series of observations of considerable extent had been made with the new circle, that BESSEL thought himself authorised to announce it as a positive astronomical fact, no longer to be confounded with possible error of observation and reduction, but as a thing

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to be accounted for by some distinct physical cause. On the nature of this cause he even hazarded a speculation, doubtless a very bold one, viz. that *Sirius* and *Procyon*, in which the observed deviation from uniformity is regarded by him as fully established, are really double stars, one of the individuals only, however, being luminous; and that the variability in question arises from their relative orbitual motion about their common centre of gravity. Time only, and assiduous observation, can elucidate this curious subject.

Though very far from having exhausted the catalogue of BESSEL's purely astronomical discoveries and researches, the limits of this notice require us now to pass to the mention of his highly important investigations on subjects connected more immediately with our own globe, viz. geodesical measurements, the determination of standards of weight and length, the length of the pendulum, and the train of subjects therewith connected; all which afforded him opportunities of displaying a skill not less consummate as a physical experimenter, than he had already shewn as a mathematician and astronomer.

His first step in this career was the determination of the length of the simple pendulum at his own observatory. The principle of this determination is the observation of the times of vibration of two pendulums whose difference is precisely equal to a given standard of length; for which purpose a fac-simile of the toise of Peru was chosen, being a measure *aux bouts* which the principle of construction of the apparatus rendered a necessary condition. The actual vibrating pendulum was a ball suspended by a wire, the suspending apparatus being made to rest alternately on the upper end of the toise and on the flat support of its lower end, the tangent plane of the lower surface of the ball being brought to a constant level by the use of the lever of contact. The series of experiments made with this apparatus was published in the volume of *Memoirs of the Berlin Academy* for 1826, though the date of their communication and reading was two years later, the publication of the Memoirs being so much in arrear. This investigation will always be considered as forming an epoch in the history of pendulum experiments, on account of the peculiar mode in which the subject of the resistance of the air to the motion of the suspended body is taken into consideration; this renders it necessary to estimate as part of the mass set in motion the weight of the air dragged along with it. The

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researches of Mr. BAILY and Colonel SABINE have fully confirmed the necessity of taking into account this essential, though small, correction.

The determination of the same important element for the then newly erected observatory at Berlin followed in 1835. The method employed, with some slight improvements, was the same as that practised at Königsberg, and the whole process will be found in the *Memoirs of the Berlin Academy* for 1835.

The interim between these two determinations was occupied with a series of pendulum experiments of very especial physical interest and importance—a rigorous inquiry, namely, into the fundamental question whether gravity be really, in all kinds of bodies, proportional to their inertia *solely?* or, in other words, whether or not there be any thing specific or dependent on the intimate nature or chemical constitution of a body which determines the energy of its gravitating power,* the *inertia* being given? The experiments of NEWTON, though they preclude all idea of any considerable or palpable amount of such specific difference among bodies, could by no means be regarded as sufficiently exact to settle a point of such vast importance with that decision which modern science requires. All idea of such specific attraction is, however, completely done away with by the result of the elaborate series of experiments set on foot by M. BESSEL for this purpose, which form the subject of a Memoir presented to the Berlin Academy in 1832, and printed in their Memoirs for 1830; every substance examined, including meteoric iron and stony masses, having given exactly the same coefficient of gravitating intensity as compared with its inertia.

Immediately connected with the length of the seconds' pendulum is the determination of standards of weight and measure. The fixation of the Prussian standard of length, ordered by law in 1816, after remaining nineteen years in abeyance, was committed to M. BESSEL in 1835, who completed the

* It is so easy to misunderstand the true gist of this inquiry, that it may be not amiss to state it otherwise. Suppose *a pound* of gold, *a pound* of lead, and *a pound* of ice, to be formed into three spheres, and placed with their centres at the three angles of an equilateral triangle,—will they or will they not, taken two by two, attract *each other* with equal forces? The *earth* is here considered as an impartial mixture of all elementary substances.

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task assigned to him in 1837. The account of this operation, and of the comparison of the new standard with the Peru toise, which had served for the measure of the pendulum, forms the subject of a Memoir printed in 1839 by order of the Prussian Government.

Eminent as were his mathematical resources, and his aptitude for bringing them to bear in the most advantageous and effective manner upon every point of practical application, there is, perhaps, no subject among the multitude of those which at different times engaged his attention in which these qualities were more singularly called into action, in combination with his skill as an astronomer, and his perfect knowledge of instruments, than in the geodesical operations which he was about this period called upon to conduct, in conjunction with General Baeyer, for the triangulation of Eastern Prussia. Though the actual extent of this triangulation was not considerable, the extreme points connected being only about 120 English miles distant, still few trigonometrical operations have been executed of greater circumstantial importance, inasmuch as it had for its especial object to connect the operations of Struve in the north of Russia and Finland, and those of Von Tenner in the south of that empire, with those of Western and Southern Europe, from which they previously stood altogether disjoined. The triangulation of Hessia, Thuringia, Brandenburg, and Silesia, under the direction of General Müffling, had connected the Hanoverian and Danish measurements on the one hand, and those of France (and consequently also of Britain) on the other, with the Bavarian and Austrian surveys. The chain of connexion had, moreover, been carried on by the triangulation of Western Prussia and the Grand Duchy of Posen, as far as the borders of the Frische Haff, on the Baltic; and one link only was wanting between Trunz, the furthest point of this last-mentioned operation, and Memel, to bring together these detached masses, and bind them into one vast European combination. Bessel's conduct of this operation was marked, like every thing which he undertook, by the adoption of new and refined processes, both of observation and computation. The astronomical latitudes of his stations, for instance, were ascertained by the application of that peculiar mode of using the transit instrument to which allusion has already been made, to the exclusion of the zenith sector and repeating circle, which had hitherto been used for that purpose. As respects the calculation of the triangles, also, a general mode

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of treatment was now, for the first time, adopted, combining the whole system of observations in all the triangles, so as to lead to a single conclusion as to the final results of the total work, and not (as had been the practice in all previous cases) to derive by several distinct combinations several distinct conclusions, either as to the whole or to subordinate parts. In the method pursued, each triangle is supposed affected with unknown, or rather indeterminate, errors in all its angles. The observations of the angles in each, with the application of the spheroidical excess, gives a sum to which all the errors must conform *as nearly as possible.* In the language of modern computation, it affords an *equation of condition* which takes its place and acquires its due influence as an element of a final system of similar equations, whose joint solution is then accomplished by the application of that powerful process, the method of least squares, to which our knowledge of physical truth is so much indebted. In the measurement of the base, also, much ingenious contrivance and many peculiar features occur; and the operation, taken all together, will ever be regarded, apart from its adventitious circumstances of interest, as one of the most instructive geodesical measurements which has ever been performed.

These occupations unavoidably drew the attention of Bessel to the general subject of the figure of the earth, as resulting from geodesical measurements, and more especially to the best and most effectual means of availing ourselves of the vast accumulation of data obtained at such enormous cost and labour, in India, in France, in Britain, and elsewhere. To grasp the whole of this mass under one general and systematic process of reduction and calculation, appeared to him an object worthy of his powers; and this design was carried out in that powerful, regular, and at the same time highly artificial mode which had now become habitual to him, in a series of Memoirs communicated to the *Astronomische Nachrichten*, 333–336, 338. The first of these contains the general exhibition of the most advantageous mode of combining the several independent measures of meridian arcs, so as to obtain by the method of least squares the most probable result as to the dimensions of the terrestrial spheroid, and applies that method to the received values of the arcs, as given by their several measurers, taking for granted the correctness of their computation of their own triangles, and the latitudes of their extreme points. But he did not stop here. On the contrary, engaging deeper in the inquiry, he was led to enter upon a recomputation of the latitudes of all the

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principal stations in the British and Indian arcs, and finally to recompute entirely, according to the same principle of combination used in his own East Prussian triangulation, the whole system of French triangles between Montjouy and Formentera. There is, perhaps, hardly one of his numerous and laborious works calculated to give a better idea of the extreme scrupulousness of all his proceedings, and his contempt of labour where the object is to elicit truth in its most absolute form from a mass of observations of undoubted excellence, than this last calculation. A mistake, as is well known, had been committed in one part of the computation of the French triangles, by which the total distance between the parallels of these two points had been rendered erroneous to the extent of nearly seventy toises. The mistake, however, had been rectified by the independent calculations of four eminent French geodesists, and their conclusions agreed within three or four toises of each other. This, however, did not satisfy BESSEL, and he actually recalculated the whole of the work by his own method, producing a result agreeing with the mean of the four determinations alluded to within a fraction of a toise.

We are still very far from having exhausted the long catalogue of BESSEL's astronomical labours. His memoir on the precession of the equinoxes, honoured with a prize by the Berlin Academy, and his researches on the planetary perturbations, might well demand some especial notice, did not our necessary limits forbid it, and oblige us also to pass unmentioned, otherwise than generally, the astonishing host of contributions with which, from time to time, he enriched the periodical literature of astronomy. The greater proportion of these are contained in the *Astronomische Nachrichten*—so great a number indeed, and many of them of such extent, that perhaps it is not exaggerating to say that at least a fifth part of that collection (now consisting of twenty-four volumes) has emanated from his pen. The *Zeitschrift für Astronomie*, the *Königsberger Archiv für Naturwissenchaften*, the *Monathliche Correspondenz*, and the Supplements to the *Berlin Ephemeris*, contain also many and valuable communications from him.* And when it is recollected that many of these papers are essays of great length and deep interest,

* In Poggendorff's *Annalen der Physik* occur occasional communications by BESSEL: among others, a long and interesting one in vol. lxxxii. (vi. N. S.) on the adjustment of thermometers.

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abounding in profound research and new conceptions on almost every subject with which astronomers are conversant, we shall see cause to admire no less the indefatigable industry of the man than the extent and versatility of those powers which produced such a profusion of valuable matter. Some of these essays, retouched and enlarged, form part of a work entitled *Astronomische Untersuchungen*, or Astronomical Researches, two volumes of which have appeared, and a third was understood to be in preparation when his labours were arrested by illness.

In the year 1842 BESSEL, for the first and last time, visited England, and was received in a manner befitting the high estimation in which his merits were held. His unaffected and pleasing deportment, the charm of his conversation, and the rich fund of information and instruction it afforded, will be remembered with pleasure and regret by all who had the good fortune to be in his company.

There can be little doubt that he was preparing, on his return to Germany, and perhaps even before his visit to England, for an attack upon that great problem whose solution has done so much honour to LE VERRIER and ADAMS. He had, in fact, with a view to this undertaking, engaged a young and promising astronomer, Mr. FLEMMING, to reduce anew, with the utmost rigour, all known observations of *Uranus*, including the Königsberg observations of that planet, and to compare them with the tables. This was the groundwork of his intended researches. Mr. FLEMMING completed the reductions, which are in the possession of Mr. SCHUMACHER, and died soon afterwards, and the fatal malady of which, after two years of continually increasing suffering, BESSEL himself died, made its appearance and interdicted every serious labour.

The scientific character of BESSEL will have been easily collected from what has been said of particular branches of his extensive labours. One leading feature of it was the concentration of all known data on each particular subject of inquiry, with the view of expressing from them, by the highest and most refined application of mathematical and computistic power, the utmost they are capable of affording in the direction of numerical precision; and, as a means to this end, to satisfy this earnest longing after

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precise results, an equally earnest and successful endeavour to improve to the utmost all formulæ and systems of computation *as such;* that is to say, to put them before the computist in a state ready for immediate use, and to give the last precision which the state of science admits to every fundamental and every derivative coefficient. In the preface to his *Untersuchungen,* he says of himself, that he at no time felt any especial predilection for one rather than another particular branch of astronomical occupation, but that one idea was continually present to his mind—that of always working up to an *immediate* and *definite* object; either that of arriving at some positive result, more perfect than what had before been obtained, or that of removing some acknowledged obstacle which opposed at once the improvement of more than one subject. And in this remarkable passage he goes on to declare, that the desire of merely accumulating data by observation, without the intention of using them to such ends, was altogether alien to his tastes; and that the deduction of actual results from observations, by the observer himself, with a distinct view to the improvement of knowledge, appeared to him, at all times, an essential condition of success in all astronomical research.

As a mathematician, Bessel takes undoubtedly a high rank; not, indeed, as an original inventor in the abstract walks of the pure analysis, but always with a view to applications, in which, whatever occasion required its exertion, his skill was never found unequal to the task on hand, no matter what its difficulty. As a practical astronomer, his knowledge of what may be called the theory of instruments—the mode of detecting, compensating, and eliminating their errors; the influence of flexures of their limbs, tubes, and other parts; and his acquaintance with, and constant practice of, every delicacy in their use, were such as has never been surpassed. Equally great in perfecting old methods of observation and in suggesting new, the practice of the modern German school of astronomers is almost emphatically Bessel's practice; and he was deservedly looked upon as a guide and model, not only in Germany, but by Europe.

Bessel was, of course, elected into almost every academy in Europe as an Associate. He became a Foreign Member of this Society in 1822. As he advanced in years and in reputation, distinctions of a different kind were

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conferred upon him; among others, the order of the Dannebrog by the King of Denmark, and that of the Red Eagle, with the title of "Geheimer Regierung's Rath," and the order of Civil Merit by his own sovereign, whose favour he constantly experienced, and whose attentions during his last illness were of the most benignant kind, and soothed, though they could not alleviate, his sufferings.

The Baron DAMOISEAU, independently of his paper on the theory of the moon, and his tables of the satellites of *Jupiter*, contributed to the astronomy of our time a work which must form an epoch in the theory of gravitation. His tables of the moon, published in 1824, are constructed on that theory alone. From the time of NEWTON, till the period just mentioned, all tables had depended, more or less, on observation, not only for the numerical data necessary for the determination of the undisturbed orbit, but also for the values of some of the coefficients of perturbation. To DAMOISEAU we are indebted for the first tables in which all perturbations are results of the theory; and this important labour must always secure him an honourable place among the followers of NEWTON, independently of the peculiar excellence of his results and formulæ, which have induced the Astronomer Royal partially to adopt them in the Greenwich reductions referred to in another part of this Report.

Were it intended to describe the results of the century instead of the current year, the subject to which your Council now come would lose none of its prominent interest. The prediction of a new planet, on grounds derived from calculation only — the fulfilment of that prediction — the attainment of the solution of the inverse problem of perturbation — mark the years 1845 and 1846 with an importance which belongs to no period except that of the announcement of the theory of gravitation and of the publication of the *Principia*.

The circumstances under which the discovery was made add to the interest of the question, by throwing difficulty in the way of the settlement of points of opinion connected with its history. And the embarrassment is materially increased by the necessity of deciding national rights, and of guarding against the undue influence of national feeling.

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The facts connected with this singularly splendid triumph of mind over matter have been much discussed, and are now fully published. The statement made to this Society by the Astronomer Royal in November, the memoirs of M. Le Verrier, the memoir of Mr. Adams, and the statements made by Mr. Challis, and in various numbers of the *Comptes Rendus*, have put our Fellows in such possession of the absolute circumstances of the case as renders any detailed account of them unnecessary in this Report. It fortunately happens that there is no one disputed fact; but upon the construction of the facts, and upon the meaning of words, there are differences of opinion, at least as wide as those which have always existed upon the great question of the claims of Newton and Leibnitz to the invention of fluxions.

In one thing there is general agreement, namely, in giving both to M. Le Verrier and Mr. Adams the highest order of praise and admiration. As soon as they are compared, all manner of opinions are found to prevail as to their *relative* positions; but on the absolute character of the rank taken by the labours of both in the history of astronomical discovery there can be but one feeling.

Under these circumstances it will be matter of regret, but hardly, all things considered, one of astonishment, that your Council has not been able to give any verdict upon the disputed matters of opinion, nor to afford, to any conclusion, the sanction which would be considered as implied in the award of a medal to M. Le Verrier, to Mr. Adams, or to both. Such a tribute is not needed by either; and your Council distinctly request it may be understood, that in making a statement of the circumstances under which they have failed to arrive at a decision, they are simply accounting to their constituents for their own conduct, and not intending to draw any conclusion upon the controverted opinions. Perhaps there is not one among them who does not, more or less, censure the collective body to which he belongs for not adopting a positive course; while, perhaps, there are very few indeed who could agree upon any one mode of proceeding. And it is by no means improbable, that the same general wish that something had been done, and the same disagreement as to what it should be, which has prevailed in the Council, would also prevail in the Society.

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By our bye-laws, only one medal can be given in any one year; but it is in the power of a General Meeting, at the proposal of the Council, to suspend or abrogate any bye-law. Again, by the same laws, all propositions for the award of medals must be made and seconded in November, and taken into consideration in January. That no possible view of the case might be precluded from discussion, the individual members of the Council, with whom every such proposition must originate, took care that the list of those nominated for the medal in November last should contain all the names which could by possibility come into question.

The first point of discussion was, whether it would be expedient to recommend the General Meeting to suspend the existing bye-law, and to give the power of awarding more than one medal. This, it is very obvious, has in itself a question of expediency, totally independent of the particular circumstances under which the permission is sought: and a motion was made to the effect that such a course was not expedient. This motion was carried; and as it may be presumed that the grounds on which it was brought forward are those on which it was carried, the Council think it right to state those grounds.

In carefully guarding the decisions of the medal, by placing such awards wholly in the hands of the Council, and declaring that no medal shall be given by the Society at large, the latter body has made a standing confession of the very obvious truth that a large assembly of men, interested in astronomy in very different ways, and to very different extents, does not form so proper a court for the decision of delicate questions of personal merit as a smaller body chosen by themselves, out of all whose occupations will allow of their attendance, as a specified number of those who are best qualified to conduct the affairs of the Society. If we consider how many propositions it is open to any Fellow of the Society to make, and how few are made except through the Council, it would appear that the general feeling is, that the letter of the law respecting medals is only the expression of the spirit in which the Society desires that its business should be conducted.

It was contended that this spirit of our laws would be violated, to the introduction of every disadvantage which those laws were intended to avoid,

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if a more than usually difficult question were submitted to the Society, of the very kind which the Society had peculiarly delegated to the Council, even in the ordinary and easier cases. Taking it for granted that the existing law was adopted for wise reasons, it was urged that it would be highly improper to force upon the general body the public discussion of the nicest question of relative merit which has arisen for more than a century; and that it might reasonably be expected that the extremes of opinion found to exist in the Council might be taken as a low estimate of those to be looked for in a larger body. The motion founded upon this view of the case was carried.

It being then decided that no recommendation to depart from the usual course should emanate from the Council, the question to whom the *one medal* should be awarded necessarily followed. The claim first considered was that of M. Le Verrier, whose name stood first on the list. This medal being, under the circumstances, an expression of opinion upon a matter likely to be long under discussion, or at least certain to be so interpreted both at home and abroad, it seems to have been thought by several that an award to M. Le Verrier, unaccompanied by another to Mr. Adams, would be drawing a greater distinction between the two than fairly represents the proper inference from facts, and would be an injustice to the latter. Accordingly, on a ballot being taken, it appeared that the majority in favour of the proposition was not sufficient to carry it, the bye-laws requiring that no medal should be awarded upon any majority of less than three to one. No award could therefore be made; and the Council can only conclude upon this matter, that the differences of opinion prevailing among the members render it impossible for them, as a body, to offer any statement upon the controverted points of the question.

Perhaps it would not be improper to add, that in a question in which a French and English claim are mixed, in a manner which requires a perfect absence of national feeling rightly to settle, it is not to be regretted that this Society should thus have been compelled, by the action of its own laws, to refer the decision to the astronomers who are of neither of the nations thus placed in opposition.

The planet has been assiduously observed at the various observatories in

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this country and on the Continent; the Berlin series commencing on September 23, when the planet was first recognised by Dr. GALLE, and extending to December 1, is well satisfied by a circular orbit, the radius of which is considerably less than the mean distance given by M. LE VERRIER from theory. The early observations at Cambridge by Professor CHALLIS have rendered very great assistance in approximating to the elements, and the later positions obtained with the excellent meridian instruments in that observatory, and with the Northumberland equatoreal, will no doubt essentially contribute to an accurate determination of the elliptical elements. As long as the planet was visible at transit, the published positions depend for the most part on meridian observations; and when these could be no longer continued, the large refracting telescopes (now happily to be found in so many observatories) were employed with advantage in differential comparisons, which, after the exact determination of the positions of the comparison stars, will probably give places little, if at all, inferior in accuracy to the meridian observations.

Mr. LASSELL, of Liverpool, conceives that he has seen a ring, and probably a satellite, attached to the planet. The existence of the ring seems almost certain, as other observers, with far inferior telescopes, have noted some irregularity in the roundness of the planet, and Professor CHALLIS, with the Northumberland telescope, nearly coincides with Mr. LASSELL in his description of the appearance. Mr. LASSELL's instrument is a Newtonian reflector of two feet aperture, of his own workmanship, mounted equatorially, and is perhaps the most powerful light-grasper in existence which can be set upon and kept upon an object. He first employed a grinding apparatus, precisely similar to that invented by the Earl of ROSSE; but not being quite satisfied with the figure given, he has introduced a little change in the machinery, and with perfect success. The Society may feel sure that this magnificent and manageable instrument will not be idle in such hands, if Mr. LASSELL be only blest with health and leisure to give full scope to his zeal.

The planet *Astræa* was observed at Pulkowa, for the first time since her conjunction with the sun, on November 4, and again on November 13. The planet shone with the light of a star of 10-11th magnitude, which is brighter than might have been expected.

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The past year bears still stronger evidence than the preceding to the activity with which cometary astronomy has been pursued. Since our anniversary in February 1846, eight comets have been discovered, three of them by our countryman and fellow-member, Mr. HIND. A brief notice of each of these will recall to the recollection of our members the circumstances of their discovery. It will be worth while, before doing this, to draw attention again to the fact of the duplicity of BIELA's Comet, which was mentioned in the Anniversary Report of 1846, for the purpose of taking notice of a remarkable paper by Professor PLANTAMOUR, of Geneva, published in the *Astronomische Nachrichten*, No. 584. In this paper M. PLANTAMOUR derives elements for each nucleus separately, and takes rigorously into account (in the comparison between the observed and computed places of each) the perturbations experienced by them from *Venus*, the *Earth*, *Mars*, and *Jupiter*: he thus finds that the deduced places agree very well with the observed during the whole period of observation. He then calculates, by means of the elements, the distance between the two nuclei, and finds that this distance is sensibly constant during their visibility, and is rather less than two-thirds of the radius of the lunar orbit.*

M. PLANTAMOUR, in reply to a question proposed to him by the Astronomer Royal respecting the motion of revolution of the nuclei round each

* The following remarkable notice of what may have been a double comet will be found in the *Naturales Quæstiones* of SENECA, lib. vii. sect. 16:—"Ephorus vero non religiosissimæ fidei, sæpe decipitur, sæpe decipit. Sicut hic Cometen, qui omnium mortalium oculis custoditus est, quia ingentis rei traxit eventus, quum Helicen et Burin ortu suo merserit, ait *illum discessisse in* DUAS STELLAS: quod præter illum nemo tradidit. Quis enim posset observare illud momentum, quo Cometes solutus et *in duas partes* redactus est? Quomodo autem, si est qui viderit Cometen in duas dirimi, nemo vidit fieri ex duabus? Quare autem non adjecit, in quas stellas divisus sit, quum aliqua ex quinque stellis esse debuerit?"

SENECA's account of Comets is controversial, and not very clear in matter or style. A comet is reported to have been seen in the year when Helice and Buris, two towns of Achaia, were destroyed by an earthquake; Olymp. 101, 4. EPHORUS, in relating this fact, seems to have asserted that the comet separated into two parts, which SENECA tries, not very successfully, to prove to be an absurdity. It was an opinion of some early philosophers that comets were formed by the casual junction or approximation of other stars; and SENECA infers, in the last sentence, that these could only be some of the five known *planets*, since they *alone* are known to move. EPHORUS was an eye-witness, for he was alive, and most likely at an advanced age, forty years after the appearance of the comet.

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other, has given the results of his investigation on this subject, by which it appears that the inclination of the line joining the nuclei to the plane of the orbit of the principal nucleus is pretty nearly constant, but that its projection has a considerable motion of revolution on that plane, in the order of the signs.

The first comet whose discovery is to be noticed is that which was found by Father De Vico, on the 20th of February, 1846. The discoverer was not able to observe it again, but it was refound by M. Brorsen (a student of philosophy at Kiel) on March 8, in a search especially directed to it at the request of Professor Schumacher. It was well observed at many of the principal observatories.

On the 26th of February, M. Brorsen discovered a comet in *Pisces*, which it was at first thought might prove identical with De Vico's comet, discovered on February 20. This, however, was not the case; and it appears tolerably certain that it moves in an elliptic orbit with a period of rather more than five years. Another periodical comet of short period is thus added to our system.

On the 30th April, M. Brorsen discovered a second comet in *Pegasus*, which was extensively observed, and of which several sets of parabolic elements have been computed. M. Oudemans found that an elliptic orbit, with a period of 500 years, represented all the observations very well. M. Wichmann also obtained similar elliptic elements.

On the 26th of June, Dr. C. N. F. Peters, when at the Neapolitan Observatory of Capodimonte, discovered a comet in the constellation *Scorpio*. It was observed by him on the day of its discovery, and on the two following days; and rough parabolic elements were forwarded by him to Professor Schumacher on June 29. It was repeatedly oberved by M. Peters till the 21st of July; but it was searched for in vain by other observers. The elements, therefore, rest solely on the Neapolitan observations. M. Peters computed correct parabolic elements from four normal places, derived from the whole series of observations. M. D'Arrest computed two sets of parabolic elements, but found that it was impossible to represent the whole series

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of observations by any parabola. He therefore computed an elliptic orbit, which represented the observations pretty well, the time of revolution of the comet being about sixteen years.

The next comet in order of time was discovered independently by Father De Vico and Mr. Hind, on the same night, viz. on the 29th of July. So nearly are the claims to its discovery balanced between these observers, that if we consider *him* to be the discoverer who *saw* it first, the praise belongs to De Vico; but if *he* be considered the discoverer who gave a place of it from observations first in order of time, Mr. Hind deserves the merit. Father De Vico compared it with a star whose place he had not determined, at a time preceding Mr. Hind's observation; and the place of the comet recorded by him as deduced by comparison with a *known* star follows the place given by Mr. Hind. Mr. Hind published elements deduced from his own observations, and an ephemeris of the comet, on August 4. The parabolic elements that have been computed differ much from each other; they are, in fact, but rough approximations. Not many observations of it were made, the weather being unfavourable during the time of its visibility.

The indefatigable observer De Vico discovered another comet, in *Ursa Major*, on the 23d of September; this being the sixth due to his exertions, including that which has just been mentioned. This comet appears to have been observed only three times subsequently to its discovery.

The next discovered comet on our list was found in *Coma Berenices*, by Mr. Hind, on the morning of the 19th of October. The cloudy weather which prevailed at that time prevented its reobservation by himself or any other observer. The meeting will undoubtedly sympathise with Mr. Hind in thus having his well-merited honours snatched from him a second time by circumstances over which he had no control. He may rest assured that the sense of his merits, both in England and on the Continent, is in no wise interfered with, and that his labours and zeal in every department of cometary astronomy are thankfully acknowledged and appreciated.

The discovery of a new comet in *Cepheus*, at the South Villa Observatory, on the 6th of February of the present year, has just rewarded Mr. Hind for his unwearied activity.

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In our remarks on the progress of astronomy during the past year, the attempt of M. FAYE to determine the parallax of the star *Groombridge*, No. 1830, by means of comparative transits, must not pass without notice. It will be, perhaps, remembered, that ARGELANDER found this star to have an annual proper motion, amounting to about 7″, which is greater than that yet recognised as belonging to any other star in the heavens. M. FAYE thought this star well adapted for an attempt to discover the variation of its proper motion, by means of comparisons of its right ascension at different periods of the year with another small star of the 9–10th magnitude in its neighbourhood, which is probably not sensibly affected by proper motion, the investigation of its parallax forming a natural and related object of the inquiry. He laid before the French Institute, in August last, the results of nearly six months' observations of differences of right ascension, the results of which were a trifling correction of the assumed mean difference of right ascensions of the compared stars and of their relative proper motion, and a parallax amounting to rather more than one second. The resulting parallax seemed, by a rigorous scrutiny of the equations of condition, as well established as it could be by so short a period of observation; but in December last M. FAYE laid before the Institute a continuation of his observations, extending over nearly four additional months, which completely confirms the former value of the parallax, the deduced amount differing from the preceding by a quantity scarcely appreciable, and the equations of condition being absolutely incapable of being satisfied without it. The observations having been carried on during the greater part of a year, we may consider that this result, remarkable as it is, is already deserving of considerable credit, and justifies the presumption that those stars which are found to have the most conspicuous proper motions are the proper objects of parallactic inquiries, in preference to any considerations of apparent magnitude. It is also easy for any person provided with a moderately good equatoreal to verify, without great labour, M. FAYE's result. The star of comparison used by M. FAYE is probably too faint to be unexceptionably observed with telescopes having object-glasses of less than five inches' diameter; but there is fortunately a star considerably brighter, which follows *Groombridge* 1830, at an interval of nearly seven minutes of time, and which can be easily compared with it. It is hoped, therefore, that members of this Society who have adequate instrumental means and leisure at their command will think the result arrived at by M. FAYE a proper subject for verification.

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It was mentioned in the Report of last year that the direction of the Observatory of Edinburgh had been confided to Professor Piazzi Smyth, second son of our President. Professor Smyth has not been able as yet to commence a system of observations on his own account, as he had previously to arrange and reduce the immense arrear of observations which his lamented predecessor had accumulated, out of all proportion to his physical strength or limited establishment. The task is proceeding rapidly; one volume, the sixth of the series, is just published, and we may speedily expect the following volumes. On considering his means, and the present unsupplied wants of astronomy, Professor Smyth has pretty well resolved on the following plan. Relinquishing the sun, moon, planets, and Nautical Almanac stars to Greenwich, and the nicest extra-meridian measurements to Cambridge and Oxford, he proposes,—*First*, to supply a new catalogue every year of such stars as may be wanted for fundamental points, or have some particular claims to notice; *Secondly*, to fix such stars as have been made points of reference by good observers for valuable differential observations in the past or current year.

The first-mentioned class of stars he means to reobserve after a certain time, and, if his life and health be spared, a third time. In this way, besides being sure of forming an excellent uniform and extensive standard catalogue, he hopes that the minute changes which may be detected will lay a safe foundation for researches into the nature and motion of our system, and the relation which it bears to the component parts of the visible heavens.

The completion of the altitude and azimuth instrument, intended for the extension of lunar observations at the Royal Observatory, has been seriously delayed by an accident. It is now, however, finished, and nearly set up in its place.

The Society are aware of the general principles of construction adopted for this instrument; that it is made in as few pieces of metal as possible (even the microscopes being formed in the same cast with the grand base, or grand uprights), no adjustment whatever being permitted. Perhaps, also, the following point is worthy of mention: It had long been to the Astronomer Royal a matter of serious uneasiness, that, in every instrument which

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had come under his notice, the astronomer was dependent on the perfect skill and continual assistance of the instrument-maker for the accuracy of form of the pivots, and might suffer either by his negligence or by the ordinary wear of metal, without the possibility of correcting or even detecting the fault. To the pivots of *vertical* axes this remark does not apply, because, by the use of a level attached to the revolving apparatus, any error of the pivots may be detected; but it applies to the pivots of all *horizontal* or *inclined* axes. There probably is not at this time in existence a single transit instrument of which it can be asserted, as known, that the pivots are not elliptical with the axes of the two ellipses inclined in any two different positions (for the application of the ordinary transit-level gives no indication whatever of this error). As it is in the power of the astronomer to measure any error of graduation, or indeed any other error in the construction of his instruments, it appeared discreditable that this error of non-circularity of pivots alone should be placed beyond his reach. To remedy this, as relates to the horizontal axis of the altitude and azimuth instrument, the following arrangement has been made:—Fine points have been planted on the ends of the pivots, as near to the centre as Mr. SIMMS could place them, but without any power of adjustment. The frame of the instrument carries two large perforated cocks (one opposite to the end of each pivot) and in these are inserted micrometer microscopes for viewing the points. These microscopes can be so turned, that the position of each point can be measured either with respect to its horizontal ordinate, or with respect to its vertical ordinate. The process of observation is, to set the circle to every 10° (or any other equal interval) of pointer-reading (which we will call θ), and to measure every horizontal ordinate; then in the same manner to measure every vertical ordinate. Considering each of these measures as composed of a constant, of the effects of eccentricity, and of the effects of irregularity, one will be expressed by

$$a+b\,.\,\cos\theta+c\,.\,\sin\theta+x,$$

and the other by

$$e+c\,.\,\cos\theta-b\,.\,\sin\theta+y.$$

By rules, into the details of which we cannot enter, the most probable values of a, b, c, e, are found, and then substituting these in every individual measure, all the individual values of x and y are found. The pivots, as turned

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by the engineer, have already been examined in this way, and the results, as regards the extreme accuracy of the method (as well as the goodness of the engineer's work in this instance), are most satisfactory. And the Astronomer Royal expresses his hope that transits and other instruments will, in future, be mounted with express reference to the attachment of microscopes, or equivalent apparatus, for the examination of the motion of the pivots.

We are informed that an eight-inch object-glass for the Liverpool equatoreal has been received from M. MERZ, of Munich, and the construction of the instrument is proceeding under the direction of the Astronomer Royal. He proposes to adopt the contrivance of an hour circle which shews true sidereal time, as in the Northumberland equatoreal, and to keep it *perpetually* in motion. Most of the members present will probably recollect the excellent use that was made of this arrangement by Professor CHALLIS in his search for the new planet.

The construction of a new standard imperial yard is slowly but steadily progressing. The methods devised for perpetuating the measure, which have been approved of by the Astronomer Royal, promise at least to keep the measure, when once defined, within tolerably close limits. An apparatus is provided for measuring and comparing which will render the observation itself simple and satisfactory, though at considerable cost, and in a manner requiring some exposure for the observer. The means for estimating and measuring the temperature seem to be within reach. It is probable that a single reading of the microscopes will shew the expansion of the bar corresponding to $\frac{1}{5}^{\circ}$ of Fahrenheit, and it is certain that neither the expansions of the metals at moderate temperatures, nor any thermometers which can be procured ready-made from the makers, can be relied upon to very minute quantities. Thermometers sufficiently delicate and accurate to rival the microscopic part of the apparatus are now preparing; and though much tedious labour must be gone through, it is hoped that this object may be effected. The pier and measuring apparatus will soon be erected in the cellars of the apartments of the Society, where members who are interested in the subject can gratify their curiosity, and, if they please, take a share in the work.

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The printing of the Reduction of the Greenwich Lunar Observations from 1750 to 1830 is now about three-fourths finished. The corrections of the elements of the moon's orbit have been deduced from them, and their publication is deferred only because, in the final examination of the proof-sheets of the reductions, trifling errors are occasionally discovered. The following points have been ascertained with a certainty which cannot be affected by any small changes to be hereafter made in the computations. *First*, It is certain that the moon's mean place is affected with some slowly changing inequality, of which at present theory gives no explanation. It may be a periodical inequality of long period, or it may be an error in the theoretical secular change of the moon's mean motion, combined with an error in the assumed mean motion in the present century. It is well known that the existence of such an inequality was suspected (we can scarcely say proved) by Burg, and that Laplace gave an empirical equation for its correction; it has, however, been satisfactorily proved by Poisson and Lubbock, that no equation of this form can attain a magnitude sufficient to account for the observed inequality. If there really is an error in the secular alteration of the moon's mean movement, it may become very important in the computation of the distant eclipses and other observations of antiquity. This error would also probably be shared by the mean movements of the moon's longitude of node and longitude of perihelion; and it is worthy of remark, that with respect to the longitude of node (an element upon which eclipses give us considerable information, almost free from the effects of possible errors in the other elements) several astronomers have suspected the existence of an error in the calculations applying to the earlier eclipses. Some remarks to this effect are made by Mr. Baily, in his cursory allusions to the eclipse of Agathocles (in his earliest astronomical paper); but a far more important discussion has been published in the present year by Seyffarth, in his *Chronologia Sacra*. He has shewn that, in a vast number of instances, the recorded phenomena will agree well with the phenomena given by the tables, and that in many instances eclipses which before were impossible become possible, if we alter the tabular place of the moon's node for the earliest recorded eclipses by about $5^{\circ}\frac{1}{2}$, and for later eclipses by a smaller quantity; and in no one instance, if we remember correctly, are the phenomena made less accordant with the tables by this change. The whole subject well deserves the attention of the theoretical physical astronomer. *Secondly.*

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The only slow change which theory has yet exhibited in the inclination of the moon's orbit to the earth's orbit, is that depending on the ellipticity of the earth; which may be represented by supposing the moon's orbit, during the retrogradation of its nodes, to have respect, not to the plane of the earth's orbit, but to a plane slightly inclined to it, and passing through the intersection of the earth's orbit with the earth's equator. The observations, however, shew that there is, undoubtedly, a slow oscillation, or balancing, of the moon's orbit upon the line, in its own plane, at right angles to that intersection. The Astronomer Royal has learnt, in verbal communication with Professor HANSEN, that the combination of the regress of the moon's nodes with the secular change in the plane of the earth's orbit will introduce an apparent movement, hitherto overlooked by theorists, resembling this; and it seems probable that this may prove to be a new instance of the agreement of the results of highly cultivated theory and carefully reduced observations.

The form in which the results of the Lunar Reductions are printed has been arranged expressly with the view of affording facilities to those who may desire to correct, either the arbitrary elements of the moon's motion, or the coefficients of equations which ought strictly to be deduced from those arbitrary elements, but of which, nevertheless, an empirical correction is sometimes desirable. And the Astronomer Royal wishes to make it known, that if any person desires at the present time to examine into the value of the coefficient of any inequality, he yet possesses some facilities of which the long continuance cannot be assured.

Within a few months there have been received in this country copies of M. STRUVE's description of the Central Observatory of Pulkowa (forming the first volume of the *Annales* of the Observatory). By the liberality of M. STRUVE, a copy of this work has been appropriated to the Library of this Society; and the attention of the members is called to it, not only on account of the care with which every part of it has been prepared, and the splendour with which it is presented to the reader, but also on account of the interesting record of the history of the Observatory, and the clear exposition of the principles which have guided every arrangement. The volume of plates which accompanies it contains plans of the ground, plans and sections of the

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buildings in various degrees of detail, and plans of the instruments as complete, and of their separate parts, all executed in the first style of art. The letterpress contains, among other things, an explanation of the purposes to which the energies of the Observatory are to be devoted: of these, some are local, others are subordinate to the determination of geographical points in the Russian empire; but the matter of general astronomical science, which is to be the special subject of observation, is *Stellar Astronomy;* taking this term in so wide a sense as to embrace, not only physical observations of double stars and nebulæ, but also determinations of the elements of aberration, nutation, refraction, &c., and the formation of extensive catalogues of stars. Some observations of the sun will enter incidentally into this plan, but, generally speaking, the observations of the bodies of the solar system (comets included) does not enter into the recognised scheme for Pulkowa, although ample instrumental means are provided in case any astronomer there should think it desirable to pursue these subjects. It were much to be desired that every director of an observatory would, after equally mature consideration, decide upon his plans with equal distinctness, and pledge himself to them with equal determination.

The volume terminates with a classified Catalogue of the Library of the Pulkowa Observatory, probably the most complete in the world as regards astronomy, and the subjects closely related to it.

The King of Prussia, some years ago, directed that a first-class observatory should be erected at Bonn, and selected our Associate, Professor Argelander, to be its director. While the building was in progress, Professor Argelander carried on his observations in a wooden temporary observatory, a mere hut, which was large enough to admit of a five-foot transit and a clock. He has published the results of his labours from May 27, 1841, to April 12, 1844, in a quarto volume of 500 closely printed pages. The work consists of 204 zones of observations, on Bessel's model, comprising the stars from 45° of north declination (where Bessel left off) to 80°. So far as can be judged from the singularly clear description given by the author of the means which he took to secure accuracy, and of the tests to which he has subjected his results, we feel confident that the zones of Argelander are quite worthy of their place as a complement and con-

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tinuation of the zones of BESSEL. All the necessary means for reduction are given in the same page with the observations; and when it is said that we have thus in one volume of moderate price and dimensions, the data for determining the magnitudes and exact mean places of about 22,000 stars, for a definite epoch, any further comment would be superfluous.

It has often been a matter of regret, and sometimes a ground of reproach, that the vast country of the United States has shewn so little interest for the science of astronomy. This apathy, at any rate, exists no longer. Observatories fully equipped have been erected at many places: some are already poducing, and others giving full promise of, excellent work. We can only mention here those institutions which have made themselves known to us by forwarding observations and publications to the Society or to our members.

In the course of last year, a volume of *Astronomical Observations made at the Naval Observatory at Washington*, by Lieut. J. M. GILLISS, U.S.N., was printed by order of the senate of the United States. These observations were originally undertaken for the purpose of determining differences of longitude with the stations which might be occupied by the expedition sent out under Capt. WILKES, U.S.N. in 1838 and the following years. Lieut. GILLISS, however, to whom the charge of these occasional observations was committed, conceived that he could usefully extend his operations, and directed his attention to other stars beside those which lie in the moon's path, or are necessary for determining the errors of the instrument. In this way he has not only satisfactorily fulfilled his original task, but enriched astronomy with a catalogue in right ascension of 1248 stars in different parts of the heavens, but chiefly in or near the zodiac. The preface contains a full account of his instruments and modes of reduction. The observations for each year are kept separate. In one section, the observations, instrumental corrections, and apparent right ascensions, are set down at one opening of the book; in a second section is given the reduction to the mean right ascension for the beginning of the year; and a third section contains the partial catalogue for the year. Finally, all the partial catalogues are collected into a general catalogue for 1840; and, to make that catalogue more generally useful, Lieut. GILLISS has added the north polar distances, annual precessions, and proper motions from the B. A. Catalogue, together

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with the errors of the B. A. Catalogue in right ascension. It is probable that the results of this catalogue in right ascension are quite equal to those of European observatories, and the way in which the steps are stated enables any one to examine the position of any particular star with very little trouble. This valuable contribution to astronomy and geography has such intrinsic merit as to entitle it to the most favourable consideration from all lovers of those sciences; and Lieut. GILLISS adds, that the success of his labours "has been the occasion of the foundation of a permanent naval observatory."

The observations of the U. S. Naval Observatory for 1845 have been received within a very few days: they form a large quarto volume. This valuable work contains a complete description of the Washington Observatory, illustrated with numerous engravings of the instruments; extensive details as to the adjustments, &c., of the instruments; numerous observations with the transit, mural circle, and prime-vertical transit, well and completely reduced; and a collection of auxiliary tables. The lateness of the receipt of this volume prevents us from entering in detail into the plan of the observations; but we have said enough to shew that our brethren of the West have entered nobly on the course of astronomical observation, and we think that we may worthily congratulate both them and ourselves on this application of their characteristic energy.*

The readers of the *Monthly Notices* will have remarked observations from Professor BOND, and computed orbits by Professor PEIRCE, of Cambridge University, U. S. An equatoreal instrument, similar in size and mounting to that of Pulkowa, is now being constructed by MERZ, of Munich, for the Cambridge U. S. Observatory; we presume, at the cost of the state of Massachusetts.

The most remarkable undertaking, however, and that which does, perhaps, most credit to the energy of the Americans, is the erection of an equatoreal telescope of twelve inches' aperture (by MERZ, of Munich), at the thriving

* The duplicity of BIELA's comet was first remarked at the Washington Observatory by Lieut. MAURY, and subsequently and independently by Professor CHALLIS, with the Northumberland equatoreal.

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and spirited town of Cincinnati. The funds were obtained by subscription from the individual citizens, on the solicitation of Mr. O. M. MITCHEL, who has undertaken the charge of the Observatory. Mr. MITCHEL has also undertaken the editorship of "the *Sidereal Messenger*, a monthly journal devoted to astronomical science," in which there is a most striking account of the manner in which this great undertaking was accomplished. If as much skill be displayed in working the instrument as has been shewn in procuring it, the observatory at Cincinnati will soon be celebrated among its compeers.

Within a few months a Memoir has appeared which has excited considerable attention, the treatise "On the Central Sun" (*Die Centralsonne*), by M. MÄDLER, the astronomer who was first favourably known by his labours on the large map of the moon, and is now director of the observatory of Dorpat. The object of this paper is to shew that it is possible to examine the apparent, and to assign the real, motions of the stars in reference to a dynamical theory of their motions. M. MÄDLER commences by observing, that, whatever be the law of mutual attraction between bodies as distant as are the stars (whether it be or be not the law of the inverse square of the distance), it does not appear that there is any where one star of such magnitude that the others, or any others, can be regarded in the relation of planets or satellites to it, and therefore we cannot expect to find any thing so simple as the Keplerian law among the motions of the stars. The only way in which we can expect to treat successfully the motion of a star is to suppose that the stars are, to a great extent, pretty uniformly distributed through space, and then we may predicate a law of resultant attraction which will be tolerably accurate for the stars near to the centre. If the form of the limit of the great cluster of stars is nearly spherical, any one star at no great distance from the centre will be attracted towards that centre with a force nearly proportional to the distance: if the form of the limit is a surface compressed between two planes (as the appearance of the Milky Way leads us to suppose that of our stellar system to be), M. MÄDLER thinks (but, as it appears to us, without sufficient reason) that the law will be different. In any case, however, the stars near the centre, which are describing orbits round the centre, will move with much smaller linear velocity than the more distant stars. M. MÄDLER then discusses what will be the apparent motions of the stars as viewed from our sun, which is one of them, or from the earth

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accompanying the sun; and he discusses specially the apparent motions of the stars which are nearer to the centre than our sun is. He then proceeds to apply these theoretical considerations to the state of the heavens as we observe it. First, it is assumed that the direction of the motion of the solar system is well established by the investigations of Sir W. HERSCHEL, M. ARGELANDER, and M. OTTO STRUVE. Then M. MÄDLER shews that a point somewhere in the group of the *Pleiades*, and probably not far from *η Tauri*, possesses the characteristics of the central point. These are,—that the proper motions of the stars in its immediate neighbourhood are very uniformly equal, and in a direction opposite to the motion of our sun; and that in examining the proper motions of the stars further and further from that point they become successively larger and larger.

M. MÄDLER then enters upon a curious calculation of the distance of our sun from this centre. It is founded upon the assumption that 61 *Cygni* and our sun are equally distant from the centre, and that the distance of 61 *Cygni* from our sun is well known. With these assumptions, and the proper motions of 61 *Cygni* and *η Tauri*, he finds that the parallax of *η Tauri* is 0″·0061, or that its distance is thirty-four millions of times as great as the distance of the earth from the sun. The proper motion of *η Tauri* gives us for the periodic time of our sun round the centre, 18,200,000 years. And the orbital velocity of our sun is about thirty English miles in a second of time.

It will readily be understood that we do not allude to these determinations as being numerically exact, or even as being certainly correct in theory. But we are anxious to communicate the substance of a very remarkable train of speculation, and at the same time to point out the importance of accurate determinations of the places of stars. Let it not be supposed that it is sufficient to determine the places of a few principal stars accurately, and to give approximate places for a more extensive catalogue. The speculations in M. MÄDLER's paper are almost entirely founded on examination of the proper motions of small stars; and no observations and no catalogues of stars can be in any degree subservient to the foundation of these speculations, or of any other speculations on our cosmical system, unless they are so accurate as to give the proper motions, and the variations of proper motions, of all the stars with the utmost practicable accuracy.

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The configuration of the British islands is singularly favourable to the measurement of an arc of longitude, and the trigonometrical survey connects the extreme points with a few well-conditioned triangles. These considerations induced the Astronomer Royal to propose, and the Government, at his suggestion, to carry into effect, the determination by chronometers of the difference in longitude between the Royal Observatory and the trigonometrical station of Feagh Main, in the Island of Valentia, and nearly at the extreme west of Ireland.

As a particular account of this operation is on the very eve of publication, and a very full abstract was published in the *Monthly Notice* for June last, there is no need to enter now into any specific detail; but we are glad to remind our Fellows that the assistance given by members of our body has been acknowledged in a very gratifying manner by the Lords of the Admiralty. The memoir of the Astronomer Royal will form a portion of the *Memoirs:* but the whole expense is defrayed by their Lordships.

In the last summer, the results of the geodetic operations at the Cape of Good Hope (subject to slight modifications only in the revision of the calculations) were transmitted to this country by Mr. Maclear, and have since been made known to the world in Schumacher's *Astronomische Nachrichten.* These results are very important. The geodetic measure having been completed as far north as the Kamies Berg, 3° 34′ north of the Cape Observatory (and also as far south as Cape Point, although on account of the form of the ground, tending to produce great local disturbance, the latter station is not used), and Bradley's sector having been used to determine the latitude, not only of the extremities of the line but also of the intermediate stations of Klyp Fontein and Heerelogement's Berg, we have now very fair means of determining the curvature of the meridian in that part of the earth. And the result is, that it does not differ certainly or sensibly from that in the northern hemisphere. La Caille's measure, it is known, gave a curvature considerably smaller; and the way in which that error was produced is very curious. La Caille's base was somewhat in error; his triangulation very slightly so: the mountains near to Cape Town produced a disturbance in the latitude of his southern station: those near to Klyp Fontein produced a still greater disturbance at the northern station; and all these causes of error

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were added together in their effects on the curvature of the meridian. Mr. MACLEAR has been able to separate these effects in the most perfect manner, by repeating all the observations at the ancient stations, and also making observations at new stations, carefully chosen with reference to the principles on which modern geodetic operations are conducted.

In reference to the subject of local disturbance, a singular discovery has been made by Major-General COLBY. The elements of the figure of the earth adopted in the Ordnance Map Office (from the article "Figure of the Earth," in the *Encyclopædia Metropolitana*), having been used as the basis for computations of the latitudes and longitudes of the principal stations in the British survey from their ascertained distances and bearings, commencing with the Royal Observatory, Greenwich; and the latitudes of several having been observed on the spot, either with RAMSDEN's zenith sector or with that now employed, it was found that at the two most important stations, Dunnose, or rather Shanklin Down, in the Isle of Wight, and Balta, near Unst, in the Shetland Islands, whose latitudes had been carefully determined with RAMSDEN's sector, there was a sensible discordance. General COLBY's first step was to verify the Dunnose latitude by observations with the new sector: it was found perfectly correct. He then shifted the sector to some points in the neighbourhood, which admitted of accurate geodetic connexion; and to his great surprise he found that, in a country of no great elevation and not very irregular form, there is a discrepancy of three seconds in an arc of one mile; or, in other words, that the curvature of stagnant water is disturbed to the extent of $\frac{1}{20}$ of the whole curvature. The latitude of the new station, as observed, agrees well with that computed from Greenwich. The sector has now been removed to Balta, and has been used in the same manner, another station for comparison having been selected there also; and it appears that a result of almost exactly the same kind as that at Dunnose has been found at Balta.

We must now advert to a subject which, though not ostensibly falling under the province of the Royal Astronomical Society, is, in reality, connected in the closest possible degree with their recognised objects. It is known to our members that the Ordnance Map of England has hitherto been constructed upon a scale of one inch to the mile (or $\frac{1}{63360}$); that the Map

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of Ireland, the noblest work of that kind which the world had yet seen, is on a scale of six inches to the mile (or $\frac{1}{10560}$); and that, at the urgent representations of many persons interested, the Government have sanctioned the mapping of certain parts of England and Scotland to the same scale. The first of the new maps (a district of Lancashire, near Garstang) has appeared, and in the beauty and minuteness of its detail (including not only every thing of topographical value which can be placed in a map, but also the traces of the lines of equal heights or level lines, giving the form of the country so accurately that a model might be constructed from it), it seems to have advanced as much upon its predecessors as its predecessors had upon all other maps. But this is not a sufficient reason for bringing this subject to the notice of the Society. The improvement which we particularly desire to mention is this. The generally accurate knowledge of the figure of the earth, the determination of many latitudes with great care by means of the ordnance zenith sector, and the accurate determination of several longitudes in the expedition for the longitude of Valentia, have now given a trustworthy scale of latitude and longitude for the British map; improved methods of calculating the latitudes and longitudes of stations have been introduced in the Ordnance Survey Office; and the latitudes and longitudes are graduated on the margin of this new map in the usual way, not to degrees as on common maps, nor to minutes as on the largest maps on which we have been accustomed to see graduations, but to *single seconds of arc.* Each of these seconds occupies about $\frac{1}{10}$ of an inch; and we may now assert that the latitude and longitude of any point in this district may be taken from the map to the tenth of a second of arc. We need scarcely mention that there will be, from local causes, trifling discrepancies between the latitude and longitude taken from the map and those observed by astronomical methods, but the value of the indication remains the same; it gives the accurate amount of the local disturbances; it serves the same purpose for the earth which accurate ephemerides serve for the heavens. It was by comparing accurately computed tabular places with observed places that the exact amount of those disturbances of *Uranus* were ascertained which have led to a determination of the position of the new planet; and we may reasonably hope that, by comparing accurately computed map-latitudes and map-longitudes with observed latitudes and longitudes, we shall arrive at results equally important as regards the internal state of the earth.

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It is understood that Major-General COLBY, under whose direction this noble work has been executed, will after no long time retire from the superintendence of the Ordnance Survey. We are assured that all those who have known the care which he has taken to place the whole survey upon a scientific basis; the labours which he has bestowed upon the invention and adjustment of geodetic and astronomical apparatus; the admirable organisation which he has introduced into the whole of his extensive department; the zeal with which he has inspired every officer and every private serving under him; and the perfection of the results which the combination of these causes has produced, will join heartily with us in offering our best wishes for his happiness in his proposed retirement. In the final work of his survey he has left us matter of national pride; and we in our degree recognise him as entitled to the thanks of the nation.

The expense of printing the *Memoirs* weighs, as will be seen from the accounts, rather heavily on the Society, and the sale is far from remunerating. It is proposed in future to print in the *Monthly Notices*, and in the *Monthly Notices only*, every thing which refers to the conduct, finances, and history of the Society, and also such observations and papers, or portions of papers, as have an immediate interest, or are in a transition state of reduction. The *Monthly Notices* will thus be rather more full, with a diminution of ultimate outlay. A copy of the *Notices* will be given with every corresponding volume of *Memoirs*, so that purchasers will really possess a more complete record of our transactions than they have at present, and at a lower price, since the repetitions will be greatly reduced and will only occur in very peculiar cases.

Notwithstanding the signs of activity at home and abroad, and while congratulating our members on the state of astronomical science, and the share which this Society has taken in its progress, we may be permitted to remark that a little want of method and perseverance is to be regretted among some of our body. Several gentlemen possess instruments quite or nearly on a par with those of our public observatories, and many have abundant instrumental means for comparative observations; but the actual produce is scanty, though of excellent quality. The zones of ARGELANDER and the catalogue of GILLISS were observed with instruments which are

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common in the British islands, and those were placed in localities far more imperfectly constructed and more inconveniently situated than our ordinary amateur observatories. Would it not be possible by some plan of co-operation, and by a well-considered division of labour, to effect some important undertaking, by which each observer's interest would be greatly stimulated and increased? Without venturing at present to sketch any definite outline, it is obvious that much might be done. The proposal of Professor Piazzi Smyth, when it comes into effect, will give every facility for the complete reduction of all satisfactory differential observations, and the basis for an accurate and detailed survey of the heavens. Leaving this for future consideration, many more extra-meridian observations might have been forwarded to the Society from its members in the course of the past year. It is probable that observations have frequently been made and registered, and even reduced, which have been kept back from a fear of shewing some inexpertness in the minutiæ of practical astronomy. Perhaps it may not be improper to say, that observations are never published except with the consent of the author, and not even then, unless creditable on their own shewing; and that the friendly advice and criticism of the Members of Council are always at the service of any Fellow, so far, at least, as their knowledge extends.

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Major-Gen. Schubert.
Prof. Schumacher.
Prof. Struve.

*** This list is independent of that published by the Council of the Royal Society, which contains various other names.

At a Meeting of the Council on Friday, May 11, 1838, it was resolved:

That the copies of Greenwich Observations, not applied for within 12 months after the day of publication, be considered as forfeited to the Society.

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A List of Public Institutions, Official and other Persons, entitled, by Resolutions of the Council, to a Copy of the Memoirs of the Society.

The Royal Society of London.
The Royal Society of Edinburgh.
The Royal Irish Academy.
The Royal Institution.
The Royal Geographical Society.
The Asiatic Society at Calcutta.
The Geological Society of London.
The London Institution.
The Royal Asiatic Society of London.
The Society for the Encouragement of Arts.
The Linnean Society of London.
The Cambridge Philosophical Society.
The Library of the Admiralty.
The Institution of Civil Engineers.
The Royal Observatory at Breslau.
The Royal Observatory at Greenwich.
The Royal Observatory at Paris.
The Observatory at Alten.
The Observatory at Armagh.
The Observatory at Bologna.
The Observatory at Brussels.
The Observatory at Cadiz.
The Observatory at Cambridge.
The Observatory at Cambridge, U.S.
The Observatory at the Cape of Good Hope.
The Observatory at Dorpat.
The Observatory at Dublin.
The Observatory at Durham.
The Observatory at Edinburgh.
The Observatory at Georgetown.
The Observatory at Helsingfors.
The Observatory at Königsberg.
The Observatory at Madras.
The Observatory at Marseilles.
The Observatory at Milan.
The Observatory at Naples.
The Observatory at Oxford.
The Observatory at Palermo.
The Observatory at Paramatta.
The Observatory at Pulkowa.
The Observatory at Trevandrum.
The Observatory at Vienna.
The Observatory at Washington.
The Observatory at Lucknow.
The Royal Academy of Sciences at Paris.
The Board of Longitude at Paris.
The Dépôt Général de la Marine.
The Imperial Academy of Sciences at St. Petersburg.
The Imperial Academy of Sciences at Vienna.
The Royal Academy of Sciences at Lisbon.
The American Philosophical Society at Philadelphia.
The Bowditch Library at Boston.
The Chetham Library, Manchester.
The Academy of Sciences at Dijon.
The Literary Society of Bombay.
The Italian Society of Sciences at Modena.
The Royal Academy of Sciences at Berlin.
The Royal Academy of Sciences at Munich.
The Royal Acad. of Sciences at Stockholm.
The Royal Society at Göttingen.
The Royal Society at Naples.
The University of Leyden.
The Society at Geneva.
The United Service Institution.
The London Mechanics' Institution.
The East India Company's Library.
The President of the Royal Society of London.
The Conductor of the Trigonometrical Survey.
The United States' Coast Survey.
The Nautical Almanac Library.
The Associates of the Society.
The Secretaries of the Society.
The Printer of the Society.

London :— Printed by George Barclay, Castle Street, Leicester Square.

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MAP

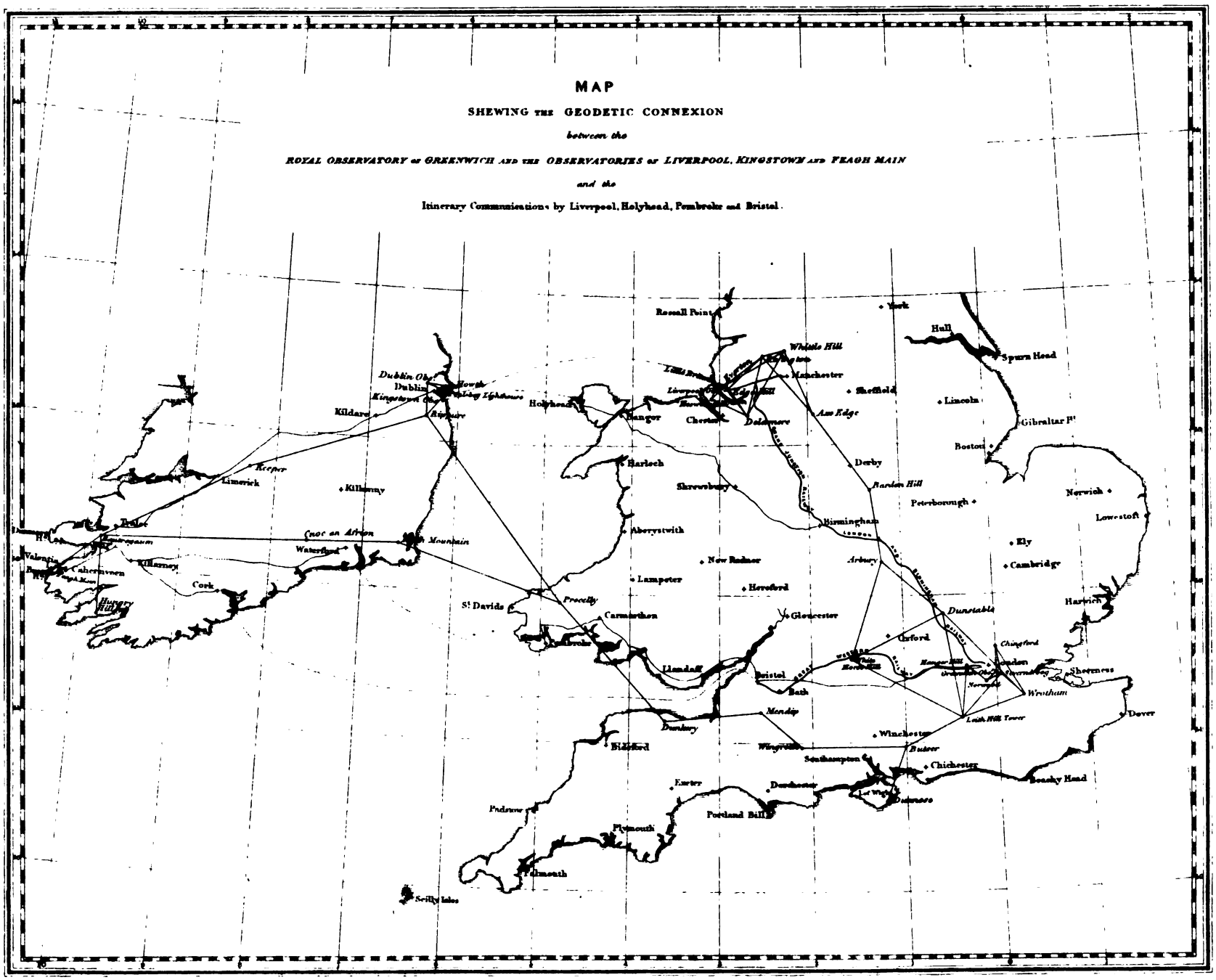
SHEWING THE GEODETIC CONNEXION

between the

ROYAL OBSERVATORY at GREENWICH AND THE OBSERVATORIES at LIVERPOOL, KINGSTOWN AND HOLYHEAD MAIN

and the

Itinerary Communications by Liverpool, Holyhead, Pembroke and Bristol.



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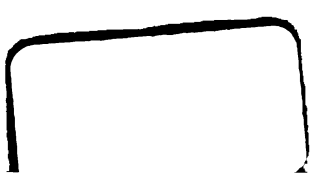

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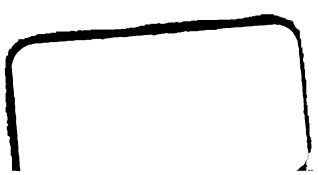

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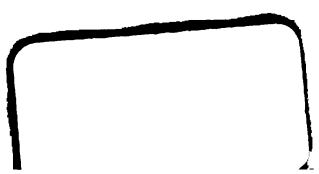

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